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Canadian Agency for Drugs and Technologies in Health

Robot-Assisted Surgery Compared with Open Surgery and Laparoscopic Surgery: Clinical Effectiveness and Economic Analyses

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Minogue Medical Inc. was provided with an opportunity to comment on an earlier version of this report. All comments that were received were considered when preparing the final report.

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Authorship

As lead author, Chuong Ho led the project protocol development, supervised the literature review, wrote the draft, revised the report, and prepared the report for publication. Khai Tran and Karen Cimon worked with Chuong Ho to evaluate the articles' relevance, assess their quality, extract data, perform subgroup analyses of the data, tabulate data for the clinical review, and complete the report. As economic lead for the report, Eva Tsakonas conducted the review of the economic literature, the primary economic evaluation, and the population impact and budget impact analyses. She also researched and wrote the section on planning and implementation, and revised the report based on reviewers' comments. Stephen Pautler and Jacques Corcos provided clinical expertise and contributed to the draft document and its revisions. Melissa Severn and Monika Mierzwinski-Urban were responsible for designing and executing the literature search strategies, for writing the section and associated appendix on literature searching, and for verifying and formatting the bibliographic references.

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Conflicts of Interest

None to declare

EXECUTIVE SUMMARY

The Issue

Given the recent introduction and increasing diffusion of robotic surgery technology into the prostatectomy, nephrectomy, hysterectomy, and cardiac surgery fields, and its high capital and operating costs, a review of the clinical and economic impact is needed to inform decisions about its acquisition, and potential or expanded use.

Objectives

The primary objectives of this Health Technology Assessment (HTA) were to assess the clinical and cost-effectiveness of robotic surgery compared with open procedures and laparoscopic procedures. We conducted a systematic review to evaluate the clinical effectiveness of robotic surgery compared with open procedures and laparoscopic procedures, followed by a systematic review of economic evaluation studies. We also conducted a primary economic evaluation of robotic surgery in one indication from a Canadian perspective and assessed robotic surgery's potential impact on health services (population impact and budget impact) in Canada.

Methods

A systematic review with meta-analyses was conducted to compare clinical efficacy between robot-assisted, open, and laparoscopic surgeries. The measures of effect for dichotomous data, such as complication rates and positive margin rates, were expressed as risk ratios with 95% confidence intervals (CI). The measures of effect for continuous data, such as operative time and length of hospital stay, were expressed as weighted mean differences with 95% CI.

A systematic review of the economic literature was conducted with the aim of assessing the economic evidence on robotic surgery. The primary economic evaluation compared robotic surgery with open surgery and with laparoscopic surgery in the most frequently performed robotic procedure in Canada (radical prostatectomy). Because clinically important between-group differences in effects (as measured using outcomes such as mortality, morbidity, general quality of life, and potential disease recurrence) could not be demonstrated based on the data obtained from the clinical review, only the relative costs of the surgical alternatives were compared in a cost-minimization analysis. This analysis was conducted from the perspective of the publicly funded health care system, and costs were estimated for the length of hospitalization. The population impact analysis estimated the potential number of hospitals in Canada that would be eligible for a robotics program and the number of patients who might be treated. A budget impact analysis was used to estimate the net program costs from an institutional perspective.

Clinical Effectiveness

During the literature search, 2,031 citations were identified. After the exclusion of articles with irrelevant study designs, populations, interventions, or outcomes, 95 studies were selected for inclusion: 51 on prostatectomy, 26 on hysterectomy, 10 on nephrectomy, and eight on cardiac surgery. A review of the included trials revealed two findings. First, there were no data from randomized controlled trials, and data on nephrectomy and cardiac surgery were limited. Second, based on primary meta-analyses of the included observational studies, robot-assisted surgery was associated with a statistically significant benefit for several clinical outcomes.

- Length of hospital stay: robot-assisted surgery was shown to be associated with statistically significantly reduced lengths of hospital stay compared with open prostatectomy, laparoscopic prostatectomy, open hysterectomy, laparoscopic hysterectomy, and laparoscopic partial nephrectomy.
- Blood loss and transfusion rates: robot-assisted surgery was associated with a statistically significant reduction in blood loss and transfusion rates compared with open prostatectomy, laparoscopic prostatectomy, and open hysterectomy.
- Positive margin rates: robot-assisted surgery was associated with a statistically significant reduction of positive margin rates compared with open prostatectomy in pT2 patients (patients whose tumours are confined to the prostate).
- Incidence of complications: robot-assisted surgery was associated with statistically significant reductions in postoperative complication rates compared with open hysterectomy and laparoscopic hysterectomy.
- Operative time: robot-assisted surgery was associated with a statistically significantly increased operative time compared with open prostatectomy and open hysterectomy, and a reduced operative time compared with laparoscopic prostatectomy.

Findings on robot-assisted cardiac surgery were scarce, but seemed to favour robot-assisted surgery for length of hospital stay.

Overall, many of the pooled estimates for comparisons of the selected indications were associated with statistically significant heterogeneity across studies. Subgroup analyses of study outcome data on study quality, study design, and removal of outliers did not show any systematic patterns. An increase in surgeons' experience was associated with reductions in operative time, length of stay, incidence of complications, and risk of positive margin rates. Given the lack of availability of randomized trials, the presence of unexplained heterogeneity in some pooled estimates, and the occasional identification of studies with conflicting findings, conclusions need to be drawn carefully from meta-analysis. In addition, statistically significant differences favouring robotic surgery were identified for several outcomes, but there is uncertainty about the clinical relevance of the size of these differences.

Economic Review and Analysis

A systematic review of the economic literature was conducted with the aim of assessing the economic evidence for robotic surgery in terms of study quality, methods, results, and relevance in a Canadian context, and a descriptive approach was used. Thirty economic analyses of the use of robotic surgery were reviewed: 15 on prostatectomy, four on cardiac surgery, two on radical nephrectomy, eight on hysterectomy, and one on multiple indications. The conclusions of the studies varied regarding the costs and cost-effectiveness of robotic surgery, as well as handling and inclusion of costs. Most studies were limited in the reporting of their methods, and one study in hysterectomy was relevant to a current Canadian setting.

In the cost-minimization analysis, shorter lengths of stay after robotic radical prostatectomy reduced hospitalization costs relative to open surgery and laparoscopic surgery. However, because of the costs of acquiring, operating, and maintaining the surgical robot, the estimated per-patient costs of the robotic technology were higher than the comparator (incremental costs compared with open surgery are $3,860 per patient and, compared with laparoscopic surgery,

$4,625 per patient). By increasing the annual caseload, the incremental costs per patient for robotic surgery can be lowered — the mean incremental costs drop significantly during the first 200 procedures. A probabilistic sensitivity analysis suggests that robotic surgery is more expensive than open surgery and laparoscopic surgery in approximately 75% of cases, with cost-saving situations for robotic surgery being largely attributed to variation in hospitalization costs.

Health Services Impact

The population impact analysis suggests that up to 31 Canadian centres could adopt the robotic technology, assuming the centres that do so have characteristics similar to the centres that already use it. Assuming that their caseloads are similar to those of operational centres, up to 4,030 robotic procedures may be performed in Canada annually. If the number of centres adopting this technology expands to include non-teaching hospitals of a similar bed capacity and hospitals with a smaller bed capacity, the number of patients being treated annually could rise to 11,050. Considering the average patient undergoing a robotic surgical procedure, and the utilization patterns in Canadian robotic centres, the net institutional costs for operating a robotics program with a new da Vinci Si Surgical System for seven years is estimated to be $2.9 million. Cardiac surgery was estimated to be the least costly indication-specific program, with net program costs of $0.9 million over seven years, and prostatectomy was estimated to be the most expensive, with net program costs of $3.5 million over seven years.

Conclusions

Based on the evidence that was included in this technology assessment, robot-assisted surgery may have an impact on several clinical outcomes in patients undergoing prostatectomy, partial nephrectomy, or hysterectomy. The benefits vary between indications. Findings regarding robot-assisted cardiac surgery were scarce but tended to favour robot-assisted surgery in terms of length of hospital stay. Comparisons between the methods of surgery regarding survival rates and time to return to work were inconclusive due to the scarcity of evidence. Given the limitations of the available evidence and uncertainty about the clinical relevance of the size of benefits of robot-assisted surgery compared with alternative approaches, decisions about the uptake of robot-assisted surgery will be complex and need to be made carefully. Robotically performed surgery is expensive compared with open and laparoscopic approaches. The investment made in acquiring this technology is large, and institutions that choose to adopt this technology need to monitor their costs and outcomes so that they can maximize its cost-effective use in their centre. To decrease costs, centres could maximize caseloads, consider keeping the robot operational for longer, if possible, and use the technology for multiple indications, particularly those with greater potential impact on patient outcomes and institutional cost savings.

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ACRONYMS AND ABBREVIATIONS

APR-DRG	All-Patient Refined–Diagnosis-Related Group
ASD	atrial septal defect
ASDR	atrial septal defect repair
BMI	body mass index
CABG	coronary artery bypass grafting
CAP	cryosurgical ablation of prostate
CI	confidence interval
CPWC	cost per weighted case
FIGO	International Federation of Gynecology and Obstetrics
HCR	hybrid coronary artery revascularization
LOS	length of stay
LPN	laparoscopic partial nephrectomy
LRH	laparoscopic radical hysterectomy
LRN	laparoscopic radical nephrectomy
LRP	laparoscopic radical prostatectomy
LTH	laparoscopic total hysterectomy
MI	myocardial infarct
MVR	mitral valve repair
NA	not available
NR	not reported
NS	not significant
OPCAB	off-pump coronary artery bypass
OPN	open partial nephrectomy
ORH	open radical hysterectomy
ORN	open radical nephrectomy
ORP	open radical prostatectomy
OTH	open total hysterectomy
PMR	positive margin rate
PORPUS	Patient-Oriented Prostate Utility Scale
PSA	prostate-specific antigen
QALY	quality-adjusted life-year
QOL	quality of life
RA	robot-assisted
RACS	robot-assisted cardiac surgery
RALP	robot-assisted laparoscopic prostatectomy
RAPN	robot-assisted partial nephrectomy
RARH	robot-assisted radical hysterectomy
RARN	robot-assisted radical nephrectomy
RARP	robot-assisted radical prostatectomy
RATH	robot-assisted total hysterectomy
RCT	randomized controlled trial
RPP	radical perineal prostatectomy
RR	risk ratio
RRP	radical retropubic prostatectomy
SD	standard deviation
WIT	warm ischemic time
WMD	weighted mean difference

1 INTRODUCTION

1.1 Background and Setting in Canada

Robotic surgery for prostatectomy, hysterectomy, nephrectomy, and cardiac surgery are four procedures of interest to Canadian jurisdictions, based on clinical importance and the current and predicted use of robotic surgery.

Prostate cancer is the most frequently occurring cancer among Canadian men, with an estimated 24,700 new cases diagnosed in 2008[1] and a lifetime risk in males estimated to be between 12% and 16%.[2] Prostate cancer is the third leading cause of cancer-related mortality among Canadian men and resulted in approximately 4,300 deaths in 2008.[1] Estimates from a Canadian prostate cancer model suggest that the average lifetime direct medical care costs for treating a patient were C$13,913 in 1996 (undiscounted).[2] In Ontario, the cost of retropubic radical prostatectomy in 2003 was approximately C$5,525.[3] The treatment of prostate cancer depends on the stage of the disease (localized, locally advanced, regionally advanced, and metastatic) and includes options ranging from simple surveillance to radiotherapy, cryotherapy, pharmacological therapy, and radical prostatectomy.[4] The likelihood of having a prostatectomy as an initial therapy is more common in younger patients; the estimated probability of choosing prostatectomy as initial therapy after diagnosis is 21.9% in 60-year-old patients and 2.2% in 80-year-old patients.[5]

Hysterectomy is performed for several indications. More than 36,000 procedures were performed in Canada in 2007-2008. In that period, the rates in Canadian jurisdictions varied from 172 per 100,000 women in Nunavut to 595 per 100,000 women in Prince Edward Island.[6] The main indications for hysterectomy in Canada in 2007-2008 were fibroids (39.4%), menstrual hemorrhage and pain (16.1%), uterine prolapse (13.7%), endometriosis (11.7%), and cancer (10.2%), with 8.8% of hysterectomies performed for other reasons (e.g., menopause disorders, ovarian diseases, and contraceptive management).[7]

In Canada, the 2005 five-year prevalence of kidney cancers in males was 48.2 per 100,000; in females, it was 31.8 per 100,000.[8] The incidence of kidney cancer is increasing, with most tumours discovered incidentally on abdominal imaging.[9-11] Surgery is the primary treatment for localized renal cell carcinoma. The decision to proceed with radical or partial nephrectomy depends on several factors, including the location and extent of the tumour in a particular kidney and the functional status of the contralateral kidney. The removal of tumours that are confined to the renal capsule leads to five-year, disease-free survival ranging from 90% to 100%. The removal of tumours that extend beyond the renal capsule is associated with 50% to 60% disease-free survival, and the removal of node-positive tumours is associated with 0% to 15% disease-free survival.[4] Partial nephrectomy is the preferred approach for small renal masses, because its use provides equivalent cancer control and better preservation of renal function compared with radical (total) nephrectomy.[12]

Coronary revascularization procedures are a surgical wait time priority in Canada.[13] Adjusting for unreported Quebec data, an estimated 20,000 coronary artery bypass graft (CABG) surgeries were performed in Canada from 2000 to 2001,[14] with some growth in procedure rates during the five years that followed.[13] Canadian estimates of the cost of hospitalization for CABG surgery range from C$11,744 per patient for off-pump surgery to C$13,720 per patient for on-pump surgery (2003 Canadian dollars),[15] suggesting total hospitalization costs of more than C$250,000,000 per year for Canada.

1.2 Overview of Technology

Surgical robots were developed to facilitate minimally invasive surgery (laparoscopy) and to assist surgeons performing surgical procedures that would otherwise not be possible with traditional open or laparoscopic techniques. Eleven Canadian hospitals have robotic systems.[16]

The most widely marketed and studied surgical robot is the da Vinci Surgical System (Intuitive Surgical, Inc., Sunnyvale, California, USA),[17] which is the only system available in Canada. The da Vinci Surgical System is a telemanipulation system in which the operating surgeon directs three or four surgical arms from a computer video console using master handles, while seated close to the patient. Since 2000, this surgical system has been approved by the US Food and Drug Administration for urologic, general laparoscopic, gynecologic laparoscopic, general non-cardiovascular thoracoscopic, and thoracoscopically assisted cardiotomy surgical procedures in adults and children.[17] The first-generation da Vinci Surgical System (the da Vinci Standard) was approved by Health Canada in March 2001. The second-generation da Vinci S Surgical System was approved in 2006, and the third-generation da Vinci Si was approved in January 2010.[18,19]

As of January 1, 2011, there had been 11 da Vinci surgical robots sold to 11 tertiary care centres in six Canadian cities (Eric Khairy, Minogue Medical Inc., Montreal, Quebec, Canada: personal communication, May 31, 2010; Minogue Medical Inc. is the Canadian distributor of the da Vinci Surgical System). The second-most-studied surgical robot, the ZEUS, is now owned by Intuitive Surgical, Inc., and is no longer being marketed.[20] Other former Computer Motion Inc. systems now owned by Intuitive Surgical, Inc., include AESOP (Automated Endoscopic System for Optimal Positioning)[21] 3000 (a voice-controlled endoscope-positioning robot), Hermes Control Center (a centralized system used to network an intelligent operating room), and SOCRATES Robotic Telecollaboration System (a system that allows shared control of AESOP 3000 from different locations).[22] Canadian licensing information about the da Vinci System appears in Appendix 1.[23,24]

Robot-assisted surgery with the da Vinci System may offer benefits to patients through the use of minimally invasive techniques, which may result in reduced blood loss, reduced blood transfusion, fewer complications, reduced postoperative pain, shorter hospital stays, and reduced recovery times. Surgeons may also benefit through improved ergonomics (for example, three-dimensional visualization and freedom, and intuitiveness of movement-enabled eye-hand coordination that may be lost in laparoscopic surgery), potentially resulting in better surgical performance.

Robot-assisted surgery is, however, associated with high capital and operating costs. The most recently obtained cost estimate of the da Vinci robot is C$2.7 million (Danny Minogue, Minogue Medical Inc., Montreal, Quebec, Canada: personal communication, December 31, 2010), with annual maintenance costs of approximately C$186,000. In addition, the average instrument cost per procedure is approximately C$2,600 (Danny Minogue, Minogue Medical Inc., Montreal, Quebec, Canada: personal communication, December 31, 2010). Factors that affect the learning curve associated with the effective use of the da Vinci Surgical System include overriding second-nature surgical approaches that are inapplicable to robotic surgery, learning new and complex techniques, and applying prior surgical experience.[25,26]

2 ISSUE

Given the recent introduction and increasing diffusion of robotic surgery technology, the indications for which it may be used, and its high capital and operating costs, a review of its clinical and economic effects is needed to inform decisions about its acquisition, potential use, and expanded use. Comparisons of robotic surgery with current procedures such as open surgery and laparoscopy are needed.

3 OBJECTIVES

The primary objectives of this Health Technology Assessment (HTA) were to assess the clinical and cost-effectiveness of robotic surgery compared with open or laparoscopic procedures. We conducted a systematic review to evaluate the clinical effectiveness of robotic surgery compared with these alternatives, followed by a systematic review of economic evaluation studies. We also conducted a primary economic evaluation of robotic surgery in radical prostatectomy from a Canadian perspective and assessed the potential health services impact of robotic surgery (population impact and budget impact) in Canada. The report addresses the following questions:

1. Compared with open or laparoscopic approaches, what is the clinical effectiveness of robot-assisted surgery (efficacy measures are listed in section 4.1.2) for:
   a. prostatectomy
   b. hysterectomy
   c. nephrectomy (because robot-assisted surgery plays a potential role in partial nephrectomy, not radical nephrectomy, the report will focus on partial nephrectomy)
   d. cardiac surgeries?

2. Compared with open or laparoscopic approaches, what is the cost-effectiveness of robot-assisted surgery for:
   a. prostatectomy
   b. hysterectomy
   c. nephrectomy
   d. cardiac surgeries?

3. What is the expected budget impact (including impact on staffing) on the Canadian provinces and territories for the adoption of robot-assisted surgery for:
   a. prostatectomy
   b. hysterectomy
   c. nephrectomy
   d. cardiac surgeries?

4. What are the expected planning and implementation issues (including maintenance of competence by staff) on the Canadian provinces and territories for the adoption of robot-assisted surgery for:
   a. prostatectomy
   b. hysterectomy
   c. nephrectomy
   d. cardiac surgeries?

4 CLINICAL REVIEW

4.1 Methods

4.1.1 Literature searches

Peer-reviewed literature searches were conducted for the clinical review. The information specialist developed all search strategies with input from the project team.

The following bibliographic databases were searched through the Ovid interface: MEDLINE, MEDLINE In-Process & Other Non-Indexed Citations, Embase, and BIOSIS Previews. Parallel searches were run in PubMed, CINAHL, and The Cochrane Library. The search strategy comprised controlled vocabulary, such as the National Library of Medicine's MeSH (Medical Subject Headings), and keywords. The main search concepts focused on surgical robotics for prostatectomy, hysterectomy, nephrectomy, and cardiac surgeries (including but not restricted to CABG and mitral valve repair surgery). Methodological filters were applied to limit retrieval to health technology assessments, systematic reviews, meta-analyses, randomized controlled trials, controlled clinical trials, observational studies, and practice guidelines. See Appendix 2 for the detailed search strategies.

The clinical search had no date limit and was limited to English and French languages. Ovid AutoAlerts were set up to send monthly updates with new literature. Updates were performed in PubMed and Cochrane Library databases.

Grey literature (literature that is not commercially published) was identified through a search of the websites of health technology assessment and related agencies, professional associations, and other specialized databases. Google and other Internet search engines were used to search for additional information. These searches were supplemented by handsearching the bibliographies and abstracts of key papers, and through contact with appropriate experts and agencies. The manufacturer of the robotic systems was also contacted for study reports.

4.1.2 Selection criteria

- Study design: randomized controlled trials (RCTs) and, when unavailable, observational studies (prospective, retrospective, and controlled clinical trials)
- Population: individuals undergoing robotic surgery for any of the selected indications
- Intervention: robotic surgery using the da Vinci System

- Comparator: open or laparoscopic procedures (because complication rates may differ between open and laparoscopic procedures, these two comparators will be analyzed separately).

Effectiveness measures: There is no primary outcome that can form the basis of a decision for surgical robotics over the other techniques. In this review, multiple outcomes were considered: disease-specific survival rate, biochemical failure rate (rising prostate-specific antigen [PSA]), positive margin rate (the rate of the presence of cancer cells at the edge of tissue that has been removed), operative time, length of hospital stay, reduction of blood loss and transfusion requirements (measured by the number of patients needing transfusion or number of transfused units needed), warm ischemic time (WIT; the time an organ remains at body temperature after its blood supply has been reduced or cut off), reduction of pain (measured using pain scales), erectile dysfunction rate (sexual function), incontinence rate (urinary function), secondary surgery for incontinence, health-related quality of life (QOL; for example, QOL scales, functional measures related to individual indications such as sexual function after prostatectomy), need for secondary treatments (for example, adjuvant or salvage radiation), time to mobilization, time to return to work, and adverse events (typical postoperative complications and specific complications for radical prostatectomy, such as bladder neck contracture rate or hernia rate).

4.1.3 Selection method

Two reviewers (CH, KC) independently screened the titles and abstracts of all citations retrieved during the literature search and, based on the selection criteria, ordered the full text of any articles they considered potentially relevant. The reviewers then independently evaluated the full texts of the selected articles, applied the selection criteria to them, and compared decisions for included and excluded studies. Disagreements were resolved through discussion until consensus was reached. Duplicate publications of the same trial were excluded.

4.1.4 Data extraction strategy

A data extraction form was designed a priori and used to tabulate all relevant study characteristics and outcomes from the included studies. Two reviewers (CH, KC) then independently extracted data, and any disagreements were resolved through discussion until consensus was reached.

4.1.5 Strategy for validity assessment

Two reviewers (CH, KC) independently assessed the validity of the clinical efficacy in the included clinical trials. Disagreements were resolved through consensus. The validity was assessed using a quality appraisal assessment form that took into account study design and study performance and that was modified from Hailey et al.'s[27] version (Appendix 3). During the assessment, studies are rated on a scale of A to E, where A (overall score 11.5 to 15.0) indicates high quality with a high degree of confidence in study findings; B (overall score 9.5 to 11.0) indicates good quality with some uncertainty about the study findings; C (overall score 7.5 to 9.0) indicates fair to good quality with some limitations that should be considered in any implementation of the study findings; D (overall score 5.5 to 7.0) indicates poor to fair quality with substantial limitations in the study findings, which should be used cautiously; and E (overall score 1 to 5.0) indicates poor quality with unacceptable uncertainty in the study findings.

4.1.6 Data analysis methods

Meta-analyses were conducted to compare clinical efficacy among robot-assisted, open, and laparoscopic surgeries where sufficient homogeneity existed. The measures of effect were calculated for each trial independently. Random effects models were used to synthesize data from included studies using the DerSimonian–Laird method.[28] The measures of effect for dichotomous data such as complication rates and positive margin rates were expressed as risk ratios (RR) with 95% confidence intervals (CI). The measures of effect for continuous data such as operative time and length of hospital stay were expressed as weighted mean differences (WMD) with 95% CI. The forest plots were computed with the "treatment" arm reflecting robot-assisted surgery, and the "control" arm reflecting open or laparoscopic surgeries. Findings are reported as "inconclusive" if the 95% CI of the overall estimate includes unity. The chi-square (chi^2) test was used to assess effect size variance, with $P < 0.10$ indicating statistically significant heterogeneity across trials. When statistically significant results were observed, efforts were made to identify the primary sources of heterogeneity, such as patient population and intervention procedure, and other factors, such as study size and study quality. In addition to subgroup analyses, a sensitivity analysis of the data was explored when applicable, to exclude studies with different traits. In circumstances where the pooling of trials was deemed inappropriate, a qualitative presentation of the findings was prepared.

4.2 Results

4.2.1 Quantity of research available

In the original literature search, 2,031 citations were identified (Appendix 4). From these, 184 potentially relevant reports were retrieved for scrutiny, and 29 reports were retrieved from search updates (Alerts) and grey literature. Of the 95 studies that were selected for inclusion, 51 studies focused on prostatectomy, 26 on hysterectomy, 10 on nephrectomy, and eight on cardiac surgery. The excluded studies are listed in Appendix 5.

4.2.2 Study characteristics

No RCTs were identified for the specified populations; all studies were non-randomized prospective or retrospective comparisons. The surgical outcomes that were commonly reported for all surgeries were operative time, length of hospital stay, postoperative complications, blood loss, and transfusion rates. The characteristics of the included studies are summarized in evidence tables (Appendix 6). To explore the potential sources of heterogeneity among included trials, additional characteristics of included studies (Appendix 7) contain reported information about surgeon expertise, outcome definitions that were used, the presence of differences between patient groups at baseline, and mechanisms for patient selection.

Prostatectomy

Of the 51 prostatectomy studies that were identified, 40 studies[29-68] compared robotic surgery with open surgery, nine studies[69-77] compared robotic surgery with laparoscopic surgery, and two studies[78,79] compared robotic surgery with open surgery and laparoscopic surgery. Two studies[34,40] reported that they received government funding. Eight studies stated that there was no industry funding.[38,39,43,44,46,49,60,73] The remainder of the studies did not report funding sources. The sample sizes ranged from 40[50] to 1,904 patients.[30] In 13 studies,[29,31,33,40,42,45,49,54,57,65,69,75,77] there was one surgeon or one surgical team in all the comparison arms. The length of follow-up varied from six weeks[53,67] to 58 months;[79] 22 studies[29,33,35,37,42,44,47,49,51,55,56,58,61,63-66,68,70,73,74,76] did not report the length of follow-up. One study[43] was assessed as being of high quality, six studies[45,48,69,72,78,79] were scored as good quality, 35 studies[29-36,38-42,44,46,47,49,52-55,57,60-62,64,65,67,68,70,71,73,74,76,77] were scored as fair to good quality, eight studies[37,50,51,56,59,63,66,75] were scored as poor to fair quality, and one study [58] was scored as poor quality. In general, most studies lost quality points because they were retrospective observational studies, and many studies provided limited information on the description and specification of the intervention, such as type of surgery or definitions of surgeons' experience.

Of 51 studies, 29 reported information on surgeons' expertise.[29,31,34,35,38-41,43-45,49-52,54,56,59,61,65,66,69-74,78,79] Of the 29 studies, 11 involved surgeons who were experienced with robotic surgery before the study, or did not include the learning curve cases in the analyses.[29,31,43,44,49,50,61,70,71,78,79] Nineteen studies were prospective observational,[32,34,39,40,42-45,47,52,53,55,56,62,64,67,72,73,78] five studies compared findings from a prospectively observed series of robotic surgical procedures with a historical cohort,[48,54,59,68,75] and 27 studies were analyses of a retrospective series of patients.[29-31,33,35-38,41,46,49-51,57,58,60,61,63,65,66,69-71,74,76,77,79] Four studies indicated a statistically significant difference in age between groups, with younger robotic surgery groups.[43,44,57,63]

For outcomes, eight studies documented operative time as skin to skin (time from opening the skin to closing the skin),[31,38,52,59,62,69,72,77] five as total time in the operating room,[48,70,71,73,74] and 37 studies provided no definition or did not report operative time.[29,30,32-37,39,41-47,49-51,53-58,60,61,63-68,75,76,78,79] Sexual function was defined as the ability to maintain an erection sufficient for intercourse with or without the use of oral phosphodiesterase-5 inhibitors. Continence was defined in most studies as no leaks or leaks less than once per week. There was no definition in the included studies of the criteria that were used to determine the need for a blood transfusion.

Hysterectomy

Of the 26 hysterectomy studies that were identified, 14 studies[80-93] compared robotic surgery with open surgery, eight studies[94-101] compared robotic surgery with laparoscopic surgery, and four studies[102-105] compared robotic surgery with laparoscopic surgery and open surgery. Three studies were publicly funded,[84,86,105] three studies indicated no industry funding,[82,89,91] and 20 studies[80,81,83,85,87,88,90,92-104] did not report the funding sources. The sample sizes ranged from 14[88] to 322.[103] Nine studies[80,83,85,91,94,96,100-102] involved one surgeon in all comparison arms. The length of follow-up varied from 14 days[100] to 1,382 days;[104] 21 studies[80,82,83,86-99,101-103,105] did not report the length of follow-up. No studies were assessed as being of high quality, five studies[83,86,89,94,104] were assessed to be of good quality, 16 studies[81,82,84,85,87,88,91,92,96,98-103,105] were scored as fair to good quality, and five studies[80,90,93,95,97] were scored as poor to fair quality. Studies lost quality points mainly because of study design (retrospective observational studies) and limited information on the study specification and analysis, such as type of surgery or definitions of surgeons' experience.

Four studies[83,84,88,89] reported information about surgeons' expertise. Four studies were prospective observational,[85,88,92,105] nine studies compared findings from a prospectively observed series of robotic surgical procedures and compared them with a historical cohort,[80,83,86,89,93,99,100,103,104] and 13 were analyses of a retrospective series of patients.[81,82,84,87,90,91,94-98,101,102] Seventeen studies showed no statistically significant differences in baseline characteristics between groups.[81,83-88,90,91,93-95,97,98,100,101,105] In six studies, there was a statistically significant difference in age between groups (in two studies, the robotic surgery groups were older;[80,104] in four studies, the open or laparoscopic groups were older[82,89,92,102]); and in four studies, there was a difference in mean body mass index (BMI; in three studies, the mean BMI was higher in the robotic surgery groups;[96,99,103] in one study, the mean BMI was higher in the open or laparoscopic group[82]).

For outcomes, among those reporting operative time, 10 studies documented it as skin to skin[80,82,83,88,89,92,97,98,103,105] and six did not report a definition.[84,87,93,95,101,102] One study reported skin to skin and total operating room time,[92] one reported console time for robotic procedures,[100] one reported console time plus set-up,[85] one reported time from insertion of Foley catheter to closing of last trocar site,[104] one reported time from Veress needle insertion and skin incision to skin closure,[94] one reported time from the start of first side wall to vaginal cuff closure,[94] two reported surgery time,[90,96] one reported from the start of anesthetic preparations to the patient leaving the operating table,[91] and one reported operating room entry to incision time, operating room time, and skin time (incision to closure).[99] No study reported on decision criteria for transfusions.

Nephrectomy

Of the 10 nephrectomy studies that were identified, nine[106-114] compared robotic surgery with laparoscopic surgery and one[115] compared robotic surgery with open surgery and laparoscopic surgery. Two studies[112,113] stated that they were not funded by industry, and eight studies[106-111,114,115] did not report the funding source. The sample sizes ranged from 22[108] to 247.[107] Six studies[109-112,114,115] involved one surgeon in all comparison arms. The length of follow-up varied from four months[115] to four years,[107] and three studies[110,112,114] did not report the length of follow-up. No studies were assessed as being of high quality, one study[111] was assessed as good quality, eight studies[106-110,113-115] were scored as fair to good quality, and one study[112] was scored as poor to fair quality. Studies most often lost quality points because of study design (retrospective observational studies) and lack of information on study specification and analysis, such as type of surgery or definitions of surgeons' experience.

Two studies noted that surgeons had no prior expertise with robotic partial nephrectomy[106,108] (one of these studies included the experience of those performing laparoscopic procedures[108]), two studies stated the involvement of surgeons who were experienced in minimally invasive renal surgery,[107,114] and one noted the involvement of one surgeon who was experienced in robotic and laparoscopic procedures.[111] Five studies did not adequately describe the expertise of surgeons performing robotic, open, or laparoscopic procedures.[109,110,112,113,115] Six studies analyzed a retrospective series of patients,[106-110,114] and four were prospective comparisons.[111-113,115] No studies reported any major differences in baseline demographics between groups.

Operative time was defined as total operating time or overall operative time in four studies,[106-109] and as time from first incision for placement of the Veress needle to placement of the dressing (including trocar placement and robot docking) in one study.[114] Five studies did not provide a definition.[110-113,115] No studies reported criteria that were used in the decision to transfuse. Another outcome that most studies reported was WIT.

Cardiac surgeries
Among the eight cardiac surgery studies that were identified, two focused on atrial septal repair,[116,117] five focused on mitral valve repair,[118-122] and one focused on CABG.[123] Two studies[120,123] stated that they were not funded by industry, and the remaining six studies[116-119,121,122] did not report the funding sources. The sample sizes ranged from 50[117,118] to 375.[120] Two studies[118,122] involved one surgeon in all comparison arms. The length of follow-up varied from 30 days[117] to 54 months;[121] two studies[119,122] did not report the length of follow-up. One study[123] was assessed as being of high quality, six studies[116-120,122] were of fair to good quality, and one study[121] was of poor to fair quality. Studies most often lost quality points because of study design (retrospective observational studies) and lack of information on study specification and analysis, such as type of surgery or definitions of surgeons' experience.

Surgeons' expertise was described in one study.[120] Two studies compared findings from a prospectively observed series of robotic surgical procedures with historical cohorts,[117,118] five were analyses of a retrospective series of patients,[116,119-122] and one used a prospective design.[123] One study[121] reported statistically significant differences in baseline characteristics between groups (the mean age was greater in the robotic surgery group); however, the robotic surgery arm of the study included five patients, compared with 123 patients in the comparison arm.

For outcomes, operative time was defined as skin to skin for one study;[116] total procedure time (including separate times for different portions) in one study;[118] bypass time in one study;[117] bypass plus aortic cross-clamp time in one study;[121] the sum of bypass time, cross-clamp time, and time to extubation in one study;[122] and total procedure time in one study.[119] It was undefined in two studies.[120,123] None of the included studies reported criteria for transfusion.

Study populations
Population characteristics from the included studies (including age, BMI, and relevant measures such as tumour stage and clinical stage) are summarized in Appendix 8.

Most prostatectomy studies included only men with clinically localized prostate cancer. Patients with prostate cancers are categorized based on the pathological status of their tumours:[124] pT2 patients have tumours that are confined to the prostate; pT3 patients have tumours with extraprostatic extension; and pT4 patients have tumours with invasion to the rectum, levator muscles, or pelvic wall.[124]

The hysterectomy studies focused on women with endometrial cancer or early stage cervical cancer. These cancers are staged according to International Federation of Gynecology and Obstetrics (FIGO) criteria.[125] The stages of endometrial cancer are:
- Stage IA: tumour limited to the endometrium
- Stage IB: invasion of less than half the myometrium
- Stage IC: invasion of more than half the myometrium
- Stage IIA: endocervical glandular involvement only
- Stage IIB: cervical stromal invasion
- Stage IIIA: invasion of serosa or adnexa, or malignant peritoneal cytology
- Stage IIIB: vaginal metastasis
- Stage IIIC: metastasis to pelvic or para-aortic lymph nodes

- Stage IVA: invasion of the bladder or bowel
- Stage IVB: distant metastasis, including intra-abdominal or inguinal lymph nodes.

In cervical cancer, the stages are:

- Stage 0: full-thickness involvement of the epithelium without invasion into the stroma (carcinoma in situ)
- Stage I: limited to the cervix
- Stage II: invades beyond cervix
- Stage III: extends to pelvic wall or lower third of the vagina
- Stage IVA: invades mucosa of bladder or rectum or extends beyond true pelvis
- Stage IVB: distant metastasis.

The nephrectomy studies focused on patients with renal cell carcinoma. The TNM system is used to describe the disease stage.[126] Among the stages, T denotes the size of the primary tumour and local extent of the disease, N denotes the degree of spread to regional lymph nodes, and M denotes the presence of metastasis.

The cardiac surgery populations included those who needed atrial septal repair, mitral valve repair, or CABG.

4.2.3 Data analyses and synthesis

4.2.3.1 Radical prostatectomy

4.2.3.1.1 Robot-assisted radical prostatectomy compared with open radical prostatectomy

Table 1 summarizes the available data for each clinical outcome and the findings from all meta-analyses and the associated measures of heterogeneity. Summary meta-analysis plots corresponding to these analyses (Figures 1 to 9 in Table 2) allow for visual inspection of between-study heterogeneity. Sensitivity and subgroup analyses are discussed after the presentation of preliminary findings.

Based on a review of the results that were obtained from the meta-analysis:

- Robot-assisted radical prostatectomy (RARP) was associated with a statistically significantly longer operative duration relative to open radical prostatectomy (ORP; WMD 37.74 minutes, 95% CI 17.13 minutes to 58.34 minutes). Seven of 19 included studies were associated with inconclusive results, two showed statistically significant effects favouring RARP, and 10 showed statistically significant effects favouring ORP.
- RARP was associated with a statistically significantly shorter length of hospital stay relative to ORP (WMD −1.54 days, 95% CI −2.13 days to −0.94 days). The point estimates of all included studies favoured RARP, and 13 of the 19 included studies were associated with statistically significant differences.
- RARP was associated with a statistically significant reduction in positive margin rate compared with ORP in pT2 patients (RR 0.6, 95% CI 0.44 to 0.83). The comparison in pT3 patients was inconclusive (RR 1.24, 95% CI 0.87 to 1.77). The pooled estimate of all studies,

including two additional large trials (Williams[66] and Breyer[32]) that did not report pT2 and pT3 subclasses, showed inconclusive results (RR 1.04, 95% CI 0.80 to 1.34).

- For complication rates, the comparison of RARP with ORP favoured RARP (RR 0.73, 95% CI 0.54 to 1.00). Most of the reported complications consisted of urinary leakage, clot retention, bleeding, ileus, wound infection, deep vein thrombosis, pulmonary embolus, urinary tract infection, post-catheter retention, and epididymitis.
- RARP was associated with a statistically significant reduction in the extent of blood loss compared with ORP (WMD −470.26 mL, 95% CI −587.98 mL to −352.53 mL). Eighteen of 21 studies showed statistically significant results favouring RARP. RARP was also associated with a statistically significantly reduced risk of red blood cell transfusion (RR 0.20, 95% CI 0.14 to 0.30).
- Comparisons of RARP and ORP for the outcomes of urinary continence after three months approached statistical significance in favour of RARP (RR 1.15, 95% CI 0.99 to 1.34). After 12 months, the pooled estimate also favoured RARP (RR 1.06, 95% CI 1.02 to 1.10).
- RARP was associated with a greater likelihood of sexual function after 12 months compared with ORP (RR 1.55, 95% CI 1.20 to 1.99).

Table 1: Primary Findings from Meta-analysis, Prostatectomy, RARP Compared with ORP

Outcome Measure	Number of Studies	Total Sample Size	Statistical Heterogeneity Measures: I^2, P-Value	Pooled Estimate [95% CI]
Operative time (minutes)	19	5,201	98.0%, < 0.00001	WMD 37.74 [17.13, 58.34]
Hospital stay (days)	19	5,554	98.9%, < 0.00001	WMD −1.54 [−2.13, −0.94]
Positive margin rate (pT2)	9	1,174	5.2%, 0.39	RR 0.61 [0.44, 0.83]
Positive margin rate (pT3)	9	479	61.4%, 0.008	RR 1.24 [0.87, 1.77]
Positive margin rate (all)	20	3511	62.6%, 0.0001	RR 1.04 [0.80, 1.34]
Incidence of complications	15	5,662	64.1%, 0.0004	RR 0.73 [0.54, 1.00]
Blood loss (mL)	21	5,568	99.4%, < 0.00001	WMD −470.26 [−587.98, −352.53]
Incidence of transfusion	18	8,730	62.3%, 0.0002	RR: 0.20 [0.14, 0.30]
Urinary continence (3 months)	5	845	66.4%, 0.05	RR: 1.15 [0.99, 1.34]
Urinary continence (12 months)	8	2,022	40.0%, 0.11	RR: 1.06 [1.02, 1.10]
Sexual competence	7	1,726	70.1%, 0.003	RR: 1.55 [1.20, 1.99]

CI = confidence interval; ORP = open radical prostatectomy; RARP = robot-assisted radical prostatectomy; RR = risk ratio; WMD = weighted mean difference.
Pooled estimates are reported as WMD for continuous measures and as RRs for dichotomous measures. For continuous outcomes, a difference < 0 favours RARP.

Table 2: Prostatectomy Meta-analyses, RARP Compared with ORP

Figure 1, operative time

Study or sub-category	Robotic surgery N	Robotic surgery Mean (SD)	Open surgery N	Open surgery Mean (SD)	Weight %	WMD (random) 95% CI
Menon (2)	30	288.00(77.80)	30	138.00(35.90)	4.97	150.00 [119.34, 180.66]
Tewari	200	160.00(43.24)	100	163.00(42.38)	5.51	-3.00 [-13.24, 7.24]
Ahlering	60	231.00(62.37)	60	214.00(55.64)	5.27	17.00 [-4.15, 38.15]
Burgess	78	262.00(70.74)	16	202.00(52.52)	4.99	60.00 [29.86, 90.14]
Boris	50	186.00(36.80)	50	184.80(46.20)	5.40	1.20 [-15.17, 17.57]
Wood	117	210.00(41.30)	89	163.00(29.00)	5.52	47.00 [37.39, 56.61]
Chan	660	208.20(44.80)	340	141.00(30.00)	5.57	67.20 [62.53, 71.87]
Durand	34	186.30(50.30)	29	186.00(48.36)	5.18	0.30 [-24.11, 24.71]
Fracalanza	35	195.60(45.00)	26	127.20(31.70)	5.33	68.40 [49.15, 87.65]
D'Alonzo	256	296.00(76.00)	280	193.00(69.00)	5.48	103.00 [90.67, 115.33]
Drouin	71	199.60(36.60)	83	208.50(76.00)	5.35	-8.90 [-27.33, 9.53]
Ou	30	205.20(102.00)	30	213.00(37.00)	4.66	-7.80 [-46.63, 31.03]
Rocco	120	215.00(58.05)	240	160.00(41.60)	5.49	55.00 [43.36, 66.64]
Zorn	296	224.00(60.50)	471	245.00(63.70)	5.53	-21.00 [-29.98, -12.02]
Di Pierro	75	330.00(54.00)	75	253.00(41.00)	5.42	77.00 [61.66, 92.34]
Doumerc	212	192.00(52.00)	502	148.00(39.00)	5.54	44.00 [36.21, 51.79]
Lo	20	306.00(85.00)	20	289.00(64.00)	4.34	17.00 [-29.63, 63.63]
Nadler	50	341.00(92.00)	50	235.00(61.00)	4.97	106.00 [75.40, 136.60]
Truesdale	99	153.40(51.30)	217	204.00(33.00)	5.50	-50.60 [-61.62, -39.58]
Total (95% CI)	2493		2708		100.00	37.74 [17.13, 58.34]

Test for heterogeneity: Chi² = 914.39, df = 18 (P < 0.00001), I² = 98.0%
Test for overall effect: Z = 3.59 (P = 0.0003)

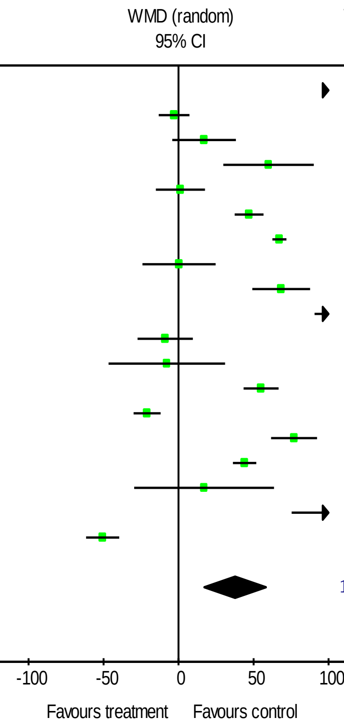


Table 2: Prostatectomy Meta-analyses, RARP Compared with ORP

Figure 2, hospital stay

Study or sub-category	Robotic surgery N	Robotic surgery Mean (SD)	Open surgery N	Open surgery Mean (SD)	Weight %	WMD (random) 95% CI
Menon (2)	30	1.50 (1.26)	30	2.30 (1.14)	5.72	-0.80 [-1.41, -0.19]
Tewari	200	1.20 (1.01)	100	3.50 (1.71)	5.95	-2.30 [-2.66, -1.94]
Ahlering	60	1.02 (0.86)	60	2.20 (1.08)	5.96	-1.18 [-1.53, -0.83]
Burgess	78	1.20 (1.09)	16	1.70 (3.83)	3.78	-0.50 [-2.39, 1.39]
Boris	50	1.00 (0.20)	50	2.40 (0.64)	6.05	-1.40 [-1.59, -1.21]
Nelson	629	1.17 (0.98)	374	1.25 (0.61)	6.08	-0.08 [-0.18, 0.02]
Wood	117	1.20 (0.84)	89	1.30 (0.95)	6.02	-0.10 [-0.35, 0.15]
Chan	660	1.10 (0.90)	340	1.30 (0.40)	6.08	-0.20 [-0.28, -0.12]
Durand	34	4.41 (3.70)	29	4.85 (2.38)	4.37	-0.44 [-1.96, 1.08]
Fracalanza	35	5.00 (4.20)	26	8.00 (3.92)	3.54	-3.00 [-5.05, -0.95]
Ham	223	3.85 (0.70)	199	7.62 (1.25)	6.05	-3.77 [-3.97, -3.57]
Prewitt	61	2.57 (2.15)	100	4.32 (2.11)	5.64	-1.75 [-2.43, -1.07]
D'Alonzo	256	1.80 (3.20)	280	2.30 (1.08)	5.91	-0.50 [-0.91, -0.09]
Drouin	71	4.40 (3.70)	83	7.00 (3.43)	4.99	-2.60 [-3.73, -1.47]
Ou	30	7.33 (2.32)	30	8.37 (2.22)	4.97	-1.04 [-2.19, 0.11]
Rocco	120	3.00 (2.52)	240	6.00 (2.94)	5.75	-3.00 [-3.58, -2.42]
Doumerc	212	2.80 (2.35)	502	5.50 (2.70)	5.93	-2.70 [-3.09, -2.31]
Lo	20	8.00 (6.00)	20	17.00 (7.00)	1.61	-9.00 [-13.04, -4.96]
Nadler	50	2.50 (2.10)	50	2.80 (1.40)	5.62	-0.30 [-1.00, 0.40]
Total (95% CI)	2936		2618		100.00	-1.54 [-2.13, -0.94]

Test for heterogeneity: Chi² = 1596.51, df = 18 (P < 0.00001), I² = 98.9%

Test for overall effect: Z = 5.05 (P < 0.00001)

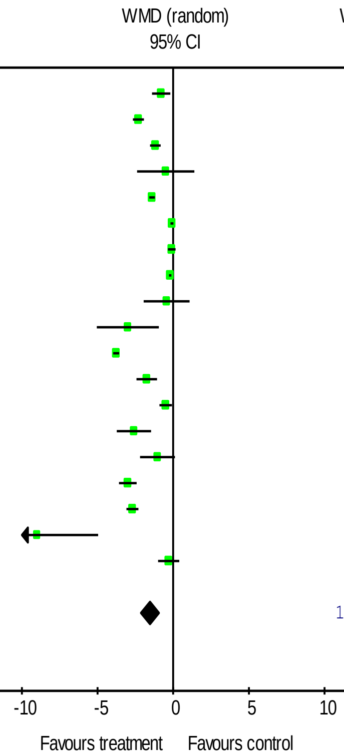


Table 2: Prostatectomy Meta-analyses, RARP Compared with ORP

Figure 3, positive margin rate

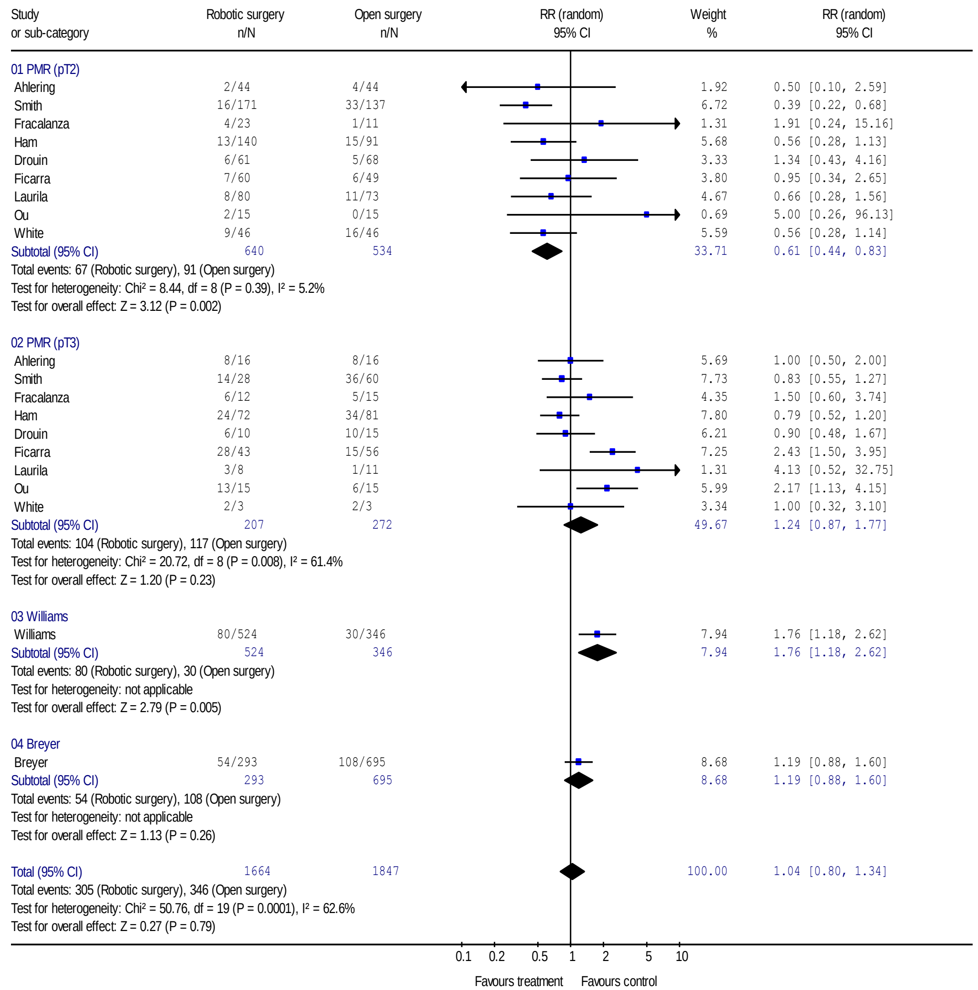


Table 2: Prostatectomy Meta-analyses, RARP Compared with ORP

Figure 4, incidence of complications

Study or sub-category	Robotic surgery n/N	Open surgery n/N	RR (random) 95% CI	Weight %	RR (random) 95% CI
Menon (2)	11/30	7/11		8.79	0.58 [0.30, 1.10]
Ahlering	4/60	6/60		4.42	0.67 [0.20, 2.24]
Boris	1/50	4/50		1.77	0.25 [0.03, 2.16]
Nelson	63/629	37/374		11.81	1.01 [0.69, 1.49]
Wood	25/117	37/89		11.34	0.51 [0.34, 0.79]
Durand	2/34	3/29		2.60	0.57 [0.10, 3.17]
Fracalanza	3/35	7/26		4.22	0.32 [0.09, 1.12]
Ham	6/223	9/199		5.59	0.59 [0.22, 1.64]
Krambeck	23/286	27/564		10.03	1.68 [0.98, 2.88]
D'Alonzo	2/256	0/280		0.95	5.47 [0.26, 113.34]
Drouin	6/71	13/83		6.33	0.54 [0.22, 1.35]
Ficarra	10/103	11/105		7.18	0.93 [0.41, 2.09]
Ou	2/30	2/30		2.21	1.00 [0.15, 6.64]
Carlsson	197/1253	159/485		13.84	0.48 [0.40, 0.57]
Nadler	16/50	12/50		8.91	1.33 [0.70, 2.52]
Total (95% CI)	3227	2435		100.00	0.73 [0.54, 1.00]

Total events: 371 (Robotic surgery), 334 (Open surgery)

Test for heterogeneity: Chi² = 38.99, df = 14 (P = 0.0004), I² = 64.1%

Test for overall effect: Z = 1.98 (P = 0.05)

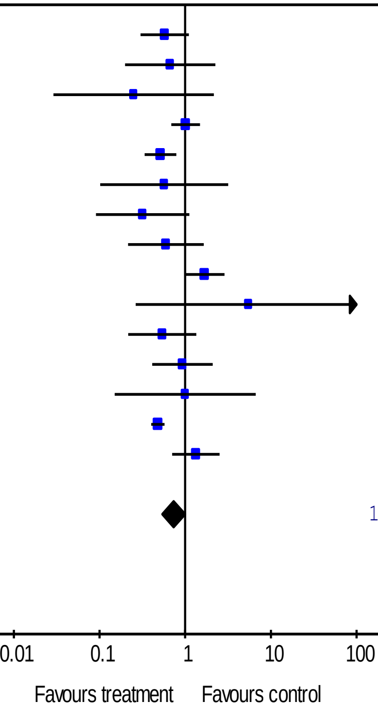


Table 2: Prostatectomy Meta-analyses, RARP Compared with ORP

Figure 5, blood loss

Study or sub-category	Robotic surgery N	Robotic surgery Mean (SD)	Open surgery N	Open surgery Mean (SD)	Weight %	WMD (random) 95% CI
Menon (2)	30	329.00(256.60)	30	970.00(611.10)	4.17	-641.00 [-878.17, -403.83]
Tewari	200	153.00(119.34)	100	910.00(573.30)	4.80	-757.00 [-870.58, -643.42]
Ahlering	60	103.00(80.34)	60	418.00(263.34)	4.94	-315.00 [-384.66, -245.34]
Burgess	78	227.00(177.06)	16	1015.00(639.45)	3.69	-788.00 [-1103.78, -472.22]
Farnham	176	191.00(149.00)	103	664.00(418.32)	4.90	-473.00 [-556.73, -389.27]
Boris	50	186.00(36.80)	50	184.80(46.20)	5.02	1.20 [-15.17, 17.57]
Madeb	100	170.00(132.60)	100	710.00(447.30)	4.87	-540.00 [-631.44, -448.56]
Miller	42	232.10(180.96)	120	490.40(308.95)	4.91	-258.30 [-336.09, -180.51]
Wood	117	151.00(117.78)	89	707.00(445.41)	4.86	-556.00 [-650.97, -461.03]
Chan	660	208.17(44.80)	340	140.90(30.00)	5.02	67.27 [62.60, 71.94]
Durand	34	307.00(239.46)	29	782.00(492.66)	4.41	-475.00 [-671.54, -278.46]
Fracalanza	35	300.00(234.00)	26	500.00(315.00)	4.67	-200.00 [-343.77, -56.23]
Ham	223	382.00(212.80)	199	896.80(270.00)	4.98	-514.80 [-561.57, -468.03]
D'Alonzo	256	287.00(317.00)	280	1087.00(853.00)	4.82	-800.00 [-907.19, -692.81]
Drouin	71	310.70(205.50)	83	821.00(582.30)	4.71	-510.30 [-644.38, -376.22]
Ficarra	103	300.00(234.00)	105	500.00(315.00)	4.92	-200.00 [-275.31, -124.69]
Ou	30	314.00(284.00)	30	912.00(370.00)	4.56	-598.00 [-764.91, -431.09]
Rocco	120	200.00(156.00)	240	800.00(504.00)	4.94	-600.00 [-669.60, -530.40]
Zorn	296	206.00(160.70)	471	1399.00(881.37)	4.90	-1193.00 [-1274.68, -1111.32]
Nadler	50	341.00(92.00)	50	235.00(61.00)	5.01	106.00 [75.40, 136.60]
Truesdale	99	157.70(105.10)	217	940.50(615.00)	4.90	-782.80 [-867.20, -698.40]
Total (95% CI)	2830		2738		100.00	-470.26 [-587.98, -352.53]

Test for heterogeneity: Chi² = 3561.39, df = 20 (P < 0.00001), I² = 99.4%
Test for overall effect: Z = 7.83 (P < 0.00001)

WMD (random) 95% CI

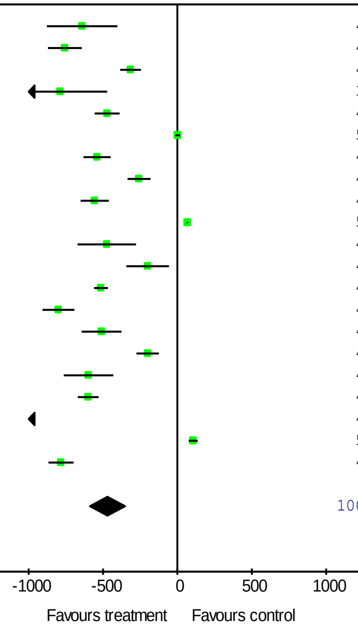
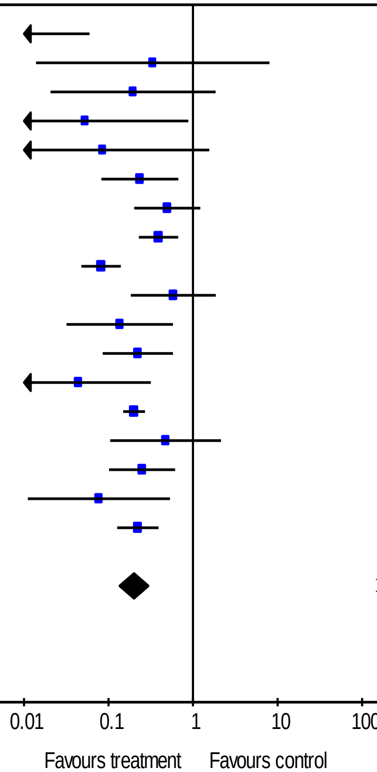


Table 2: Prostatectomy Meta-analyses, RARP Compared with ORP

Figure 6, incidence of transfusion

Study or sub-category	Robotic surgery n/N	Open surgery n/N	RR (random) 95% CI	Weight %	RR (random) 95% CI
Tewari	0/200	67/100		1.72	0.00 [0.00, 0.06]
Ahlering	0/60	1/60		1.35	0.33 [0.01, 8.02]
Farnham	1/176	3/103		2.43	0.20 [0.02, 1.85]
Boris	0/50	9/50		1.67	0.05 [0.00, 0.88]
Wood	0/117	4/89		1.58	0.08 [0.00, 1.55]
Chan	5/660	11/340		6.56	0.23 [0.08, 0.67]
Fracalanza	6/35	9/26		7.50	0.50 [0.20, 1.22]
Krambeck	15/294	77/588		10.08	0.39 [0.23, 0.67]
D'Alonzo	13/256	174/280		10.07	0.08 [0.05, 0.14]
Drouin	4/71	8/83		5.95	0.58 [0.18, 1.86]
Ficarra	2/103	15/105		4.59	0.14 [0.03, 0.58]
Ou	4/30	18/30		7.12	0.22 [0.09, 0.58]
Breyer	1/293	54/695		2.98	0.04 [0.01, 0.32]
Carlsson	58/1253	112/485		11.59	0.20 [0.15, 0.27]
Doumerc	2/212	10/502		4.36	0.47 [0.10, 2.14]
Kordan	7/830	14/414		7.50	0.25 [0.10, 0.61]
Lo	1/20	13/20		3.07	0.08 [0.01, 0.53]
Nadler	10/50	45/50		9.89	0.22 [0.13, 0.39]
Total (95% CI)	4710	4020		100.00	0.20 [0.14, 0.30]



Total events: 129 (Robotic surgery), 644 (Open surgery)

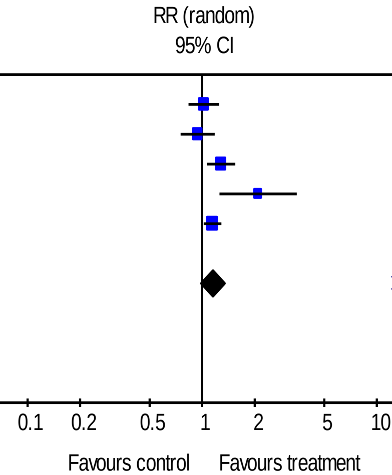
Test for heterogeneity: Chi² = 45.09, df = 17 (P = 0.0002), I² = 62.3%

Test for overall effect: Z = 8.06 (P < 0.00001)

Table 2: Prostatectomy Meta-analyses, RARP Compared with ORP

Figure 7, urinary continence at 3 months

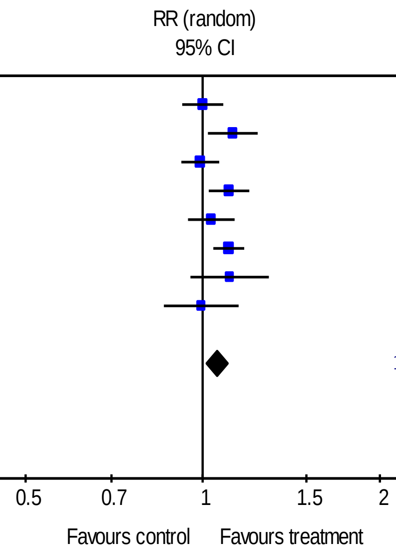
Study or sub-category	Robotic surgery n/N	Open surgery n/N	Weight %	RR (random) 95% CI
Ahlering	46/60	45/60	21.55	1.02 [0.84, 1.25]
Ball	48/82	84/135	19.82	0.94 [0.75, 1.18]
Ham	136/188	62/110	22.79	1.28 [1.06, 1.55]
Ou	23/30	11/30	7.20	2.09 [1.26, 3.48]
Di Pierro	71/75	62/75	28.64	1.15 [1.02, 1.29]
Total (95% CI)	435	410	100.00	1.15 [0.99, 1.34]



Total events: 324 (Robotic surgery), 264 (Open surgery)
Test for heterogeneity: Chi² = 11.07, df = 4 (P = 0.03), I² = 63.9%
Test for overall effect: Z = 1.80 (P = 0.07)

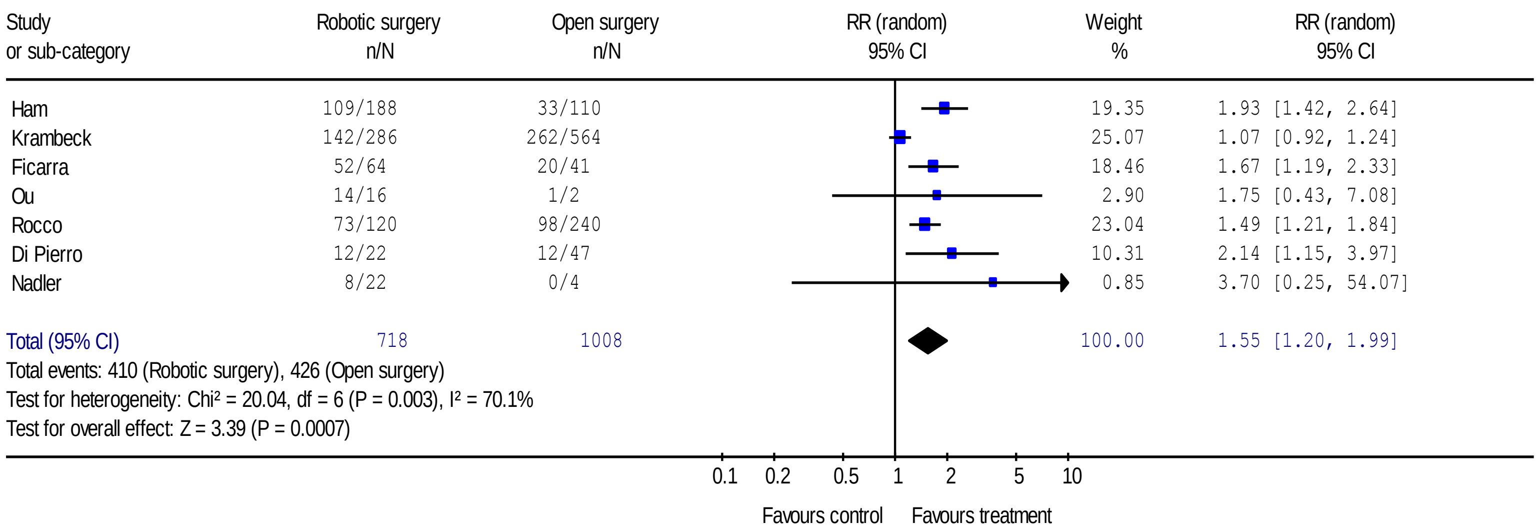
Figure 8, urinary continence at 12 months

Study or sub-category	Robotic surgery n/N	Open surgery n/N	Weight %	RR (random) 95% CI
Boris	48/50	48/50	14.53	1.00 [0.92, 1.08]
Ham	173/188	90/110	11.42	1.12 [1.02, 1.24]
Krambeck	224/286	446/564	15.73	0.99 [0.92, 1.07]
Ficarra	100/103	92/105	14.67	1.11 [1.02, 1.20]
Ou	30/30	29/30	12.44	1.03 [0.94, 1.13]
Rocco	77/79	191/217	19.04	1.11 [1.04, 1.18]
Di Pierro	40/45	60/75	5.85	1.11 [0.95, 1.30]
Nadler	39/44	41/46	6.32	0.99 [0.86, 1.15]
Total (95% CI)	825	1197	100.00	1.06 [1.02, 1.10]



Total events: 731 (Robotic surgery), 997 (Open surgery)
Test for heterogeneity: Chi² = 11.66, df = 7 (P = 0.11), I² = 40.0%
Test for overall effect: Z = 2.70 (P = 0.007)

Table 2: Prostatectomy Meta-analyses, RARP Compared with ORP

Figure 9, sexual function	

CI = confidence interval; n/N = number of events/sample population; ORP = open radical prostatectomy; RARP = robot-assisted radical prostatectomy; RR = risk ratio; SD = standard deviation; WMD = weighted mean difference.

Table 1 shows that the associated I^2 values and chi^2 tests from meta-analyses for most of the clinical outcomes indicated the presence of statistically significant heterogeneity. Efforts were made to assess the information that was collected from included studies and considered to be relevant potential sources of heterogeneity, to investigate whether any sources of heterogeneity were correlated with study outcomes. Subgroup and sensitivity analyses based on study design (prospective compared with retrospective), study quality (high or good, compared with remaining scores), and removal of outliers were explored using forest plots to identify systematic variations. Appendix 9 presents the findings of sensitivity analyses based on study design (Table A10), study quality (Table A11), and removal of outliers (Table A12). For some outcomes, conventional measures of statistical heterogeneity suggested less variation between study-level estimates when data were grouped based on study design and study quality. Sensitivity analyses that used the removal of outliers did not have an impact on the statistical heterogeneity or pooled estimates of most outcomes.

4.2.3.1.2 Robot-assisted radical prostatectomy compared with open radical prostatectomy: effect of learning curve

Table 3 summarizes findings on clinical outcomes in studies that reported data after the surgeons had overcome the learning curve on robot-assisted surgeries (post–learning curve). The table shows the comparison of these clinical outcomes between studies with experienced surgeons only and studies with experienced surgeons and less-experienced surgeons. Summary meta-analysis plots corresponding to these analyses are shown in Figures 10 to 14 (Table 4).

Based on a review of results that were obtained from meta-analysis:

- Study-specific definitions of “experienced surgeons” varied among studies, ranging from surgeons performing more than 20 robot-assisted surgeries[49] to those performing more than 1,000.[61]
- In studies with experienced surgeons, the comparisons of clinical outcomes between robot-assisted surgeries and open surgeries showed the same trends as seen in data from studies involving more experienced surgeons and less experienced surgeons: robot-assisted surgeries required a longer operative time than open surgeries and led to a shorter length of hospital stay, less blood loss, and less risk of perioperative complications than open surgeries. Compared with open surgeries, robot-assisted surgeries carried less risk of positive margin rate in patients with less advanced pathology.
- Compared with studies with experienced surgeons and less-experienced surgeons, studies with experienced surgeons only showed that surgeons’ experience accentuated the effects of robotic assistance on clinical outcomes. More surgical experience shortened operative time, shortened length of stay, reduced risk of perioperative complications, and reduced risk of positive margin rates. Blood loss, however, did not appear to be reduced with increased surgeon experience.

Table 3: Effect of Learning Curve on Clinical Outcomes		
Outcome Measure	**Total (Experienced and Less-experienced Surgeons)**	**Post–Learning Curve (Experienced Surgeons Only)**
Operative time	37 minutes longer with robot-assisted surgery (WMD 37.74, 95% CI 17.13 to 58.34)	18 minutes longer with robot-assisted surgery (WMD 18.00, 95% CI −13.26 to 49.26)
Length of hospital stay	1.5 days shorter with robot-assisted surgery (WMD −1.54, 95% CI −2.13 to −0.94)	2 days shorter with robot-assisted surgery (WMD −2.04, 95% CI −3.18 to −0.89)
Perioperative complications	27% less risk with robot-assisted surgery (RR 0.73, 95% CI 0.54 to 1.00)	46% less risk with robot-assisted surgery (RR 0.54, 95% CI 0.32 to 0.91)
Positive margin rates	For less pathologically advanced tumour (pT2): 39% less risk of PMR with robot-assisted surgery (RR 0.61, 95% CI 0.44 to 0.83). For more pathologically advanced tumour (pT3): 24% more risk of PMR with robot-assisted surgery (RR 1.24, 95% CI 0.87 to 1.77)	For less pathologically advanced tumour (pT2): 42% less risk of PMR with robot-assisted surgery (RR 0.58, 95% CI 0.39 to 0.84) For more pathologically advanced tumour (pT3): 29% more risk of PMR with robot-assisted surgery (RR 1.29, 95% CI 0.83 to 2.02)
Blood loss	470 mL less with robot-assisted surgery (WMD −470.26, 95% CI −587.98 to −352.53)	225 mL less with robot-assisted surgery (WMD −225.56, 95% CI −435.46 to −15.67)

CI = confidence interval; PMR = positive margin rate; RR = risk ratio; WMD = weighted mean difference.

Table 4: Prostatectomy Meta-analyses, RARP versus ORP (Experienced Surgeons)

Figure 10, operative time

Study or sub-category	Robotic surgery N	Robotic surgery Mean (SD)	Open surgery N	Open surgery Mean (SD)	Weight %	WMD (random) 95% CI
Ahlering	60	231.00(62.37)	60	214.00(55.64)	20.20	17.00 [-4.15, 38.15]
Burgess	20	225.00(60.75)	16	202.00(52.52)	16.96	23.00 [-14.03, 60.03]
Boris	50	186.00(36.80)	50	184.80(46.20)	20.98	1.20 [-15.17, 17.57]
Fracalanza	35	195.60(45.00)	26	127.20(31.70)	20.53	68.40 [49.15, 87.65]
Krambeck	100	211.00(56.97)	200	228.00(59.28)	21.33	-17.00 [-30.86, -3.14]
Total (95% CI)	265		352		100.00	18.00 [-13.26, 49.26]

Test for heterogeneity: Chi² = 51.89, df = 4 (P < 0.00001), I² = 92.3%
Test for overall effect: Z = 1.13 (P = 0.26)

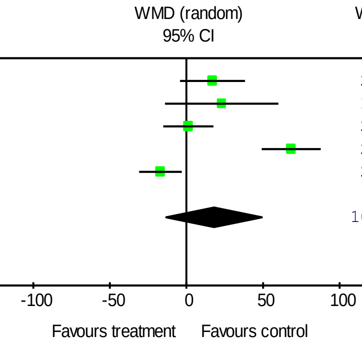


Figure 11, length of hospital stay

Study or sub-category	Robotic surgery N	Robotic surgery Mean (SD)	Open surgery N	Open surgery Mean (SD)	Weight %	WMD (random) 95% CI
Ahlering	60	1.02(0.86)	60	2.20(1.08)	27.97	-1.18 [-1.53, -0.83]
Boris	50	1.00(0.20)	50	2.40(0.64)	28.50	-1.40 [-1.59, -1.21]
Fracalanza	35	5.00(4.20)	26	8.00(3.92)	14.95	-3.00 [-5.05, -0.95]
Ham	188	3.60(0.60)	110	6.60(0.60)	28.59	-3.00 [-3.14, -2.86]
Total (95% CI)	333		246		100.00	-2.04 [-3.18, -0.89]

Test for heterogeneity: Chi² = 224.47, df = 3 (P < 0.00001), I² = 98.7%
Test for overall effect: Z = 3.48 (P = 0.0005)

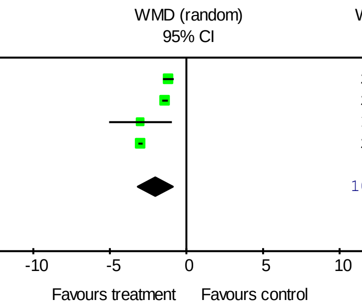


Figure 12, perioperative complications

Study or sub-category	Robotic surgery n/N	Open surgery n/N	Weight %	RR (random) 95% CI
Ahlering	4/60	6/60	18.10	0.67 [0.20, 2.24]
Boris	1/50	4/50	5.77	0.25 [0.03, 2.16]
Fracalanza	3/35	7/26	16.97	0.32 [0.09, 1.12]
Ham	4/188	8/110	19.23	0.29 [0.09, 0.95]
Ficarra	10/103	11/105	39.94	0.93 [0.41, 2.09]
Total (95% CI)	436	351	100.00	0.54 [0.32, 0.91]

Total events: 22 (Robotic surgery), 36 (Open surgery)
Test for heterogeneity: Chi² = 4.04, df = 4 (P = 0.40), I² = 1.0%
Test for overall effect: Z = 2.32 (P = 0.02)

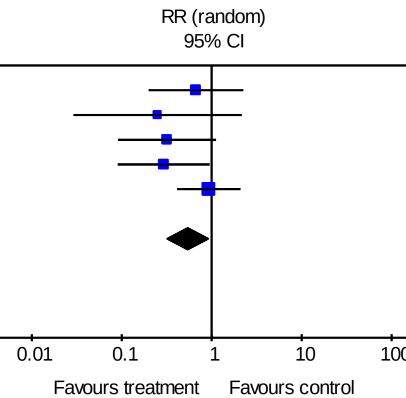


Table 4: Prostatectomy Meta-analyses, RARP versus ORP (Experienced Surgeons)

Figure 13, positive margin rates

Study or sub-category	Robotic surgery n/N	Open surgery n/N	Weight %	RR (random) 95% CI
01 PMR (pT2)				
Ahlering	2/44	4/44	4.00	0.50 [0.10, 2.59]
Smith	16/171	33/137	11.79	0.39 [0.22, 0.68]
Fracalanza	4/23	1/11	2.79	1.91 [0.24, 15.16]
Ham	9/120	4/50	6.59	0.94 [0.30, 2.90]
Ficarra	7/60	6/49	7.36	0.95 [0.34, 2.65]
Laurila	8/80	11/73	8.78	0.66 [0.28, 1.56]
Subtotal (95% CI)	498	364	41.31	0.58 [0.39, 0.84]
Total events: 46 (Robotic surgery), 59 (Open surgery)				
Test for heterogeneity: Chi² = 5.02, df = 5 (P = 0.41), I² = 0.3%				
Test for overall effect: Z = 2.84 (P = 0.004)				
02 PMR (pT3)				
Ahlering	8/16	8/16	10.33	1.00 [0.50, 2.00]
Smith	14/28	36/60	13.14	0.83 [0.55, 1.27]
Fracalanza	6/12	5/15	8.26	1.50 [0.60, 3.74]
Ham	19/59	14/42	11.66	0.97 [0.55, 1.70]
Ficarra	28/43	15/56	12.51	2.43 [1.50, 3.95]
Laurila	3/8	1/11	2.78	4.13 [0.52, 32.75]
Subtotal (95% CI)	166	200	58.69	1.29 [0.83, 2.02]
Total events: 78 (Robotic surgery), 79 (Open surgery)				
Test for heterogeneity: Chi² = 13.47, df = 5 (P = 0.02), I² = 62.9%				
Test for overall effect: Z = 1.12 (P = 0.26)				
Total (95% CI)	664	564	100.00	0.99 [0.68, 1.45]
Total events: 124 (Robotic surgery), 138 (Open surgery)				
Test for heterogeneity: Chi² = 29.56, df = 11 (P = 0.002), I² = 62.8%				
Test for overall effect: Z = 0.05 (P = 0.96)				

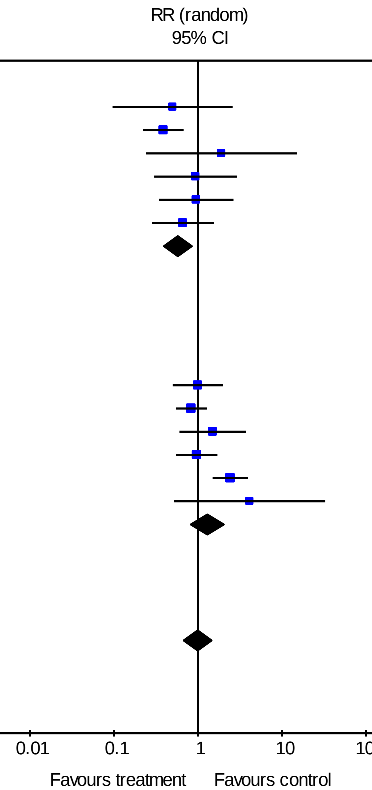
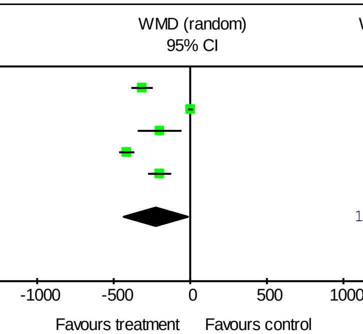


Figure 14, blood loss

Study or sub-category	Robotic surgery N	Robotic surgery Mean (SD)	Open surgery N	Open surgery Mean (SD)	Weight %	WMD (random) 95% CI
Ahlering	60	103.00(80.34)	60	418.00(263.34)	20.16	-315.00 [-384.66, -245.34]
Boris	50	186.00(36.80)	50	184.80(46.20)	20.59	1.20 [-15.17, 17.57]
Fracalanza	35	300.00(234.00)	26	500.00(315.00)	18.80	-200.00 [-343.77, -56.23]
Ham	188	333.30(213.70)	110	748.30(211.90)	20.38	-415.00 [-465.01, -364.99]
Ficarra	103	300.00(234.00)	105	500.00(315.00)	20.08	-200.00 [-275.31, -124.69]
Total (95% CI)	436		351		100.00	-225.56 [-435.46, -15.67]
Test for heterogeneity: Chi² = 315.61, df = 4 (P < 0.00001), I² = 98.7%						
Test for overall effect: Z = 2.11 (P = 0.04)						



CI = confidence interval; n/N = number of events/sample population; ORP = open radical prostatectomy; RARP = robot-assisted radical prostatectomy; RR = risk ratio; SD = standard deviation; WMD = weighted mean difference.

4.2.3.1.3 Robot-assisted radical prostatectomy compared with laparoscopic radical prostatectomy

Table 5 summarizes the data available for each clinical outcome, as well as the pooled findings from all meta-analyses and the associated measures of heterogeneity. Summary meta-analysis plots corresponding to these analyses are shown in Figures 15 to 22 (Table 6) to allow for inspection of between-study heterogeneity. Sensitivity and subgroup analyses are discussed after the presentation of preliminary findings.

Based on results that were obtained from meta-analysis:

- RARP appears to be associated with a statistically significantly shorter operative duration relative to laparoscopic radical prostatectomy (LRP; WMD −22.79 minutes, 95% CI −44.36 minutes to −1.22 minutes). Four of the included studies were associated with inconclusive point estimates, and five showed statistically significant effects favouring RARP.
- RARP appears to be associated with a statistically significantly shorter length of hospital stay relative to LRP (WMD −0.80 days, 95% CI −1.33 days to −0.27 days). The point estimates of six of seven included studies favoured RARP, and three of these studies were associated with statistically significant differences.
- For the positive margin rate, a comparison of RARP with LRP in pT2 patients showed an inconclusive result (RR 0.82, 95% CI 0.52 to 1.29), as was the case in pT3 patients (RR 0.91, 95% CI 0.57 to 1.46). All studies that were included in both meta-analyses reported inconclusive findings.
- For complication rates, the comparison of RARP with LRP was found to be inconclusive (RR 0.85, 95% CI 0.50 to 1.44). Seven of nine studies reported inconclusive estimates. The most commonly reported complications were urinary leakage, clot retention, bleeding, ileus, wound infection, deep vein thrombosis, pulmonary embolus, urinary tract infection, post-catheter retention, and epididymitis.
- RARP was associated with a statistically significant reduction in blood loss compared with LRP (−89.52 mL, 95% CI −157.54 mL to −21.49 mL). Six of the 10 studies showed statistically significant results favouring RARP. RARP was also associated with a reduced risk of transfusion (RR 0.54, 95% CI 0.31 to 0.94).
- The comparisons of RARP and LRP for the outcomes of urinary continence after three months (RR 1.10, 95% CI 0.90 to 1.34) and after 12 months (RR 1.08, 95% CI 0.99 to 1.18) were inconclusive. For each measure, one study reported a statistically significant result favouring RARP.

Table 5: Primary Findings from Meta-analysis, Prostatectomy, RARP versus LRP				
Outcome Measure	**Number of Studies**	**Total Sample Size**	**Statistical Heterogeneity Measures: I^2, P-Value**	**Pooled Estimate [95% CI]**
Operative time (minutes)	9	1,415	89.8%, < 0.00001	WMD −22.79 [−44.36, −1.22]
Hospital stay (days)	7	1,235	76.2%, 0.0003	WMD −0.80 [−1.33, −0.27]
Positive margin rate (pT2)	5	881	27%, 0.24	RR: 0.82 [0.52, 1.29]
Positive margin rate (pT3)	5	180	0%, 0.64	RR: 0.91 [0.57, 1.46]
Positive margin rate (all)	10	1061	0%, 0.55	RR: 0.89 [0.66, 1.19]
Incidence of complications	9	1,845	60.0%, 0.01	RR: 0.85 [0.50, 1.44]
Blood loss (mL)	10	1,655	90.0%, < 0.00001	WMD −89.52 [−157.54, −21.49]
Incidence of transfusion	7	1,820	0%, 0.83	RR 0.54 [0.31, 0.94]
Urinary continence (3 months)	3	556	66.4%, 0.05	RR 1.10 [0.90, 1.34]
Urinary competence (12 months)	2	400	17.7%, 0.27	RR 1.08 [0.99, 1.18]

CI = confidence interval; LRP = laparoscopic radical prostatectomy; RARP = robot-assisted radical prostatectomy; RR = risk ratio; WMD = weighted mean difference.

Pooled estimates are reported as WMD for continuous measures and as RR for dichotomous measures. For continuous outcomes, a difference < 0 favours RARP.

Table 6: Prostatectomy Meta-analyses, RARP versus LRP

Figure 15, operative time

Study or sub-category	Robotic surgery N	Robotic surgery Mean (SD)	Laparoscopy N	Laparoscopy Mean (SD)	Weight %	WMD (random) 95% CI
Menon	40	274.00(73.98)	40	258.00(87.72)	9.76	16.00 [-19.56, 51.56]
Joseph	50	202.00(54.54)	50	235.00(79.90)	11.03	-33.00 [-59.81, -6.19]
Rozet	133	166.00(44.82)	133	160.00(54.40)	12.77	6.00 [-5.98, 17.98]
Durand	34	186.00(50.30)	23	167.00(56.78)	10.76	19.00 [-9.71, 47.71]
Srinualnad	34	239.40(107.40)	34	226.50(64.20)	8.83	12.90 [-29.16, 54.96]
Trabulsi 2	205	190.00(51.32)	45	300.00(102.00)	10.48	-110.00 [-140.62, -79.38]
Drouin	71	199.00(36.67)	85	257.00(94.00)	11.71	-58.00 [-79.73, -36.27]
Hakimi	75	199.00(53.73)	75	232.00(78.88)	11.73	-33.00 [-54.60, -11.40]
Ploussard	83	145.60(34.40)	205	164.70(49.10)	12.92	-19.10 [-29.10, -9.10]
Total (95% CI)	725		690		100.00	-22.79 [-44.36, -1.22]

Test for heterogeneity: Chi² = 78.17, df = 8 (P < 0.00001), I² = 89.8%
Test for overall effect: Z = 2.07 (P = 0.04)

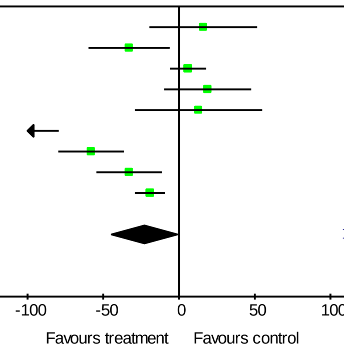


Figure 16, hospital stay

Study or sub-category	Robotic surgery N	Robotic surgery Mean (SD)	Laparoscopy N	Laparoscopy Mean (SD)	Weight %	WMD (random) 95% CI
Rozet	133	5.40(4.54)	133	4.90(1.81)	14.02	0.50 [-0.33, 1.33]
Durand	34	4.41(3.70)	23	4.91(1.82)	8.25	-0.50 [-1.95, 0.95]
Srinualnad	34	6.90(2.00)	34	8.00(2.80)	10.61	-1.10 [-2.26, 0.06]
Drouin	71	4.40(3.70)	85	6.10(2.26)	12.30	-1.70 [-2.69, -0.71]
Hakimi	75	1.95(1.64)	75	3.40(1.26)	18.28	-1.45 [-1.92, -0.98]
Ploussard	83	4.40(2.50)	205	4.60(1.70)	16.92	-0.20 [-0.79, 0.39]
Trabulsi	205	1.60(1.34)	45	2.63(0.97)	19.61	-1.03 [-1.37, -0.69]
Total (95% CI)	635		600		100.00	-0.80 [-1.33, -0.27]

Test for heterogeneity: Chi² = 25.18, df = 6 (P = 0.0003), I² = 76.2%
Test for overall effect: Z = 2.94 (P = 0.003)

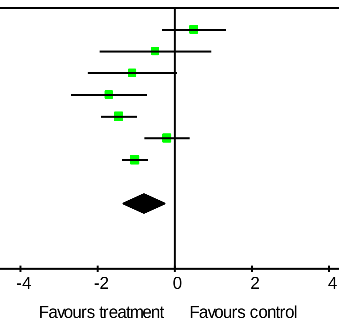


Table 6: Prostatectomy Meta-analyses, RARP versus LRP

Figure 17, positive margin rate

Study or sub-category	Robotic surgery n/N	Laparoscopy n/N	Weight %	RR (random) 95% CI
01 PMR (pT2)				
Rozet	23/110	16/103	25.48	1.35 [0.75, 2.40]
Trabulsi 2	16/163	7/35	13.02	0.49 [0.22, 1.10]
Drouin	6/61	8/70	8.51	0.86 [0.32, 2.34]
Hakimi	7/64	9/71	9.90	0.86 [0.34, 2.18]
Trabulsi	2/43	20/161	4.27	0.37 [0.09, 1.54]
Subtotal (95% CI)	441	440	61.18	0.82 [0.52, 1.29]

Total events: 54 (Robotic surgery), 60 (Laparoscopy)
Test for heterogeneity: Chi² = 5.48, df = 4 (P = 0.24), I² = 27.0%
Test for overall effect: Z = 0.86 (P = 0.39)

Study or sub-category	Robotic surgery n/N	Laparoscopy n/N	Weight %	RR (random) 95% CI
02 PMR (pT3)				
Rozet	3/23	5/30	4.87	0.78 [0.21, 2.94]
Trabulsi 2	16/42	4/10	11.77	0.95 [0.41, 2.23]
Drouin	6/10	8/15	17.77	1.13 [0.56, 2.25]
Hakimi	2/11	1/4	1.92	0.73 [0.09, 6.00]
Trabulsi	1/7	15/28	2.50	0.27 [0.04, 1.69]
Subtotal (95% CI)	93	87	38.82	0.91 [0.57, 1.46]

Total events: 28 (Robotic surgery), 33 (Laparoscopy)
Test for heterogeneity: Chi² = 2.54, df = 4 (P = 0.64), I² = 0%
Test for overall effect: Z = 0.39 (P = 0.70)

	Robotic surgery n/N	Laparoscopy n/N	Weight %	RR (random) 95% CI
Total (95% CI)	534	527	100.00	0.89 [0.66, 1.19]

Total events: 82 (Robotic surgery), 93 (Laparoscopy)
Test for heterogeneity: Chi² = 7.82, df = 9 (P = 0.55), I² = 0%
Test for overall effect: Z = 0.82 (P = 0.41)

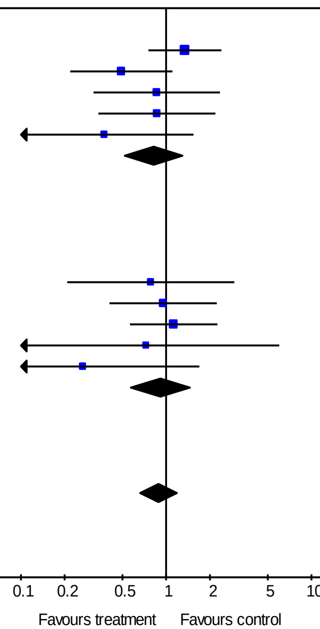


Figure 18, complication rate

Study or sub-category	Robotic surgery n/N	Laparoscopy n/N	Weight %	RR (random) 95% CI
Menon	2/40	4/40	7.28	0.50 [0.10, 2.58]
Joseph	4/50	2/50	7.21	2.00 [0.38, 10.43]
Hu	47/322	99/358	21.65	0.53 [0.39, 0.72]
Rozet	26/133	12/133	17.49	2.17 [1.14, 4.11]
Durand	2/34	1/23	4.24	1.35 [0.13, 14.06]
Srinualnad	1/34	6/34	5.20	0.17 [0.02, 1.31]
Drouin	6/71	6/85	11.86	1.20 [0.40, 3.55]
Hakimi	8/75	11/75	14.64	0.73 [0.31, 1.71]
Ploussard	3/83	13/205	10.43	0.57 [0.17, 1.95]
Total (95% CI)	842	1003	100.00	0.85 [0.50, 1.44]

Total events: 99 (Robotic surgery), 154 (Laparoscopy)
Test for heterogeneity: Chi² = 20.00, df = 8 (P = 0.01), I² = 60.0%
Test for overall effect: Z = 0.62 (P = 0.54)

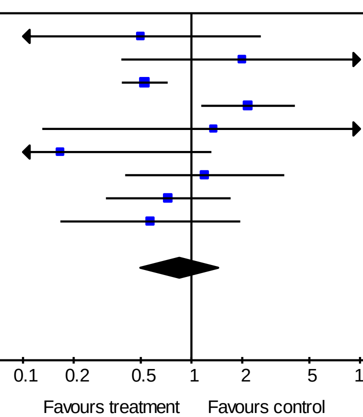


Table 6: Prostatectomy Meta-analyses, RARP versus LRP

Figure 19, blood loss

Study or sub-category	N	Robotic surgery Mean (SD)	N	Laparoscopic surgery Mean (SD)	Weight %	WMD (random) 95% CI
Menon	40	256.00(199.68)	40	391.00(230.69)	9.81	-135.00 [-229.55, -40.45]
Joseph	50	206.00(63.00)	50	299.00(40.00)	11.98	-93.00 [-113.68, -72.32]
Rozet	133	609.00(475.00)	133	512.00(302.08)	9.77	97.00 [1.33, 192.67]
Durand	34	307.00(239.46)	23	147.00(86.73)	10.07	160.00 [72.05, 247.95]
Srinualnad	34	657.40(319.10)	34	772.10(291.60)	7.80	-114.70 [-260.00, 30.60]
Trabulsi 2	205	259.00(202.00)	45	299.00(176.41)	11.11	-40.00 [-98.49, 18.49]
Drouin	71	310.70(205.50)	85	558.00(574.00)	8.35	-247.30 [-378.35, -116.25]
Hakimi	75	230.00(179.40)	75	311.00(183.49)	11.13	-81.00 [-139.08, -22.92]
Ploussard	83	469.00(380.00)	205	889.00(531.00)	9.22	-420.00 [-529.39, -310.61]
Trabulsi	50	287.00(223.86)	190	370.00(218.30)	10.75	-83.00 [-152.38, -13.62]
Total (95% CI)	775		880		100.00	-89.52 [-157.54, -21.49]

Test for heterogeneity: Chi² = 89.72, df = 9 (P < 0.00001), I² = 90.0%
Test for overall effect: Z = 2.58 (P = 0.010)

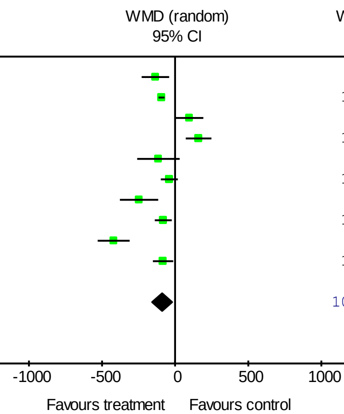


Figure 20, incidence of transfusion

Study or sub-category	Robotic surgery n/N	Laparoscopy n/N	Weight %	RR (random) 95% CI
Menon	0/40	1/40	3.14	0.33 [0.01, 7.95]
Joseph	0/50	0/50		Not estimable
Hu	5/322	8/358	25.80	0.69 [0.23, 2.10]
Rozet	4/133	13/133	26.40	0.31 [0.10, 0.92]
Trabulsi 2	4/205	2/45	11.39	0.44 [0.08, 2.32]
Drouin	4/71	5/85	19.41	0.96 [0.27, 3.43]
Ploussard	2/83	9/205	13.86	0.55 [0.12, 2.49]
Total (95% CI)	904	916	100.00	0.54 [0.31, 0.94]

Total events: 19 (Robotic surgery), 38 (Laparoscopy)
Test for heterogeneity: Chi² = 2.14, df = 5 (P = 0.83), I² = 0%
Test for overall effect: Z = 2.18 (P = 0.03)

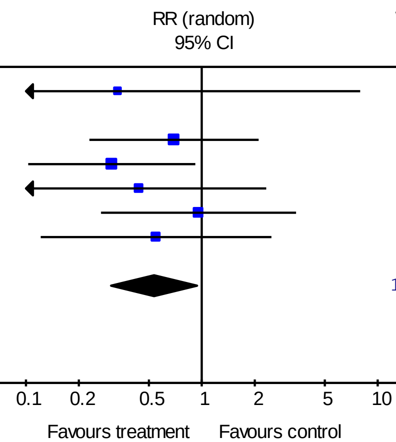


Table 6: Prostatectomy Meta-analyses, RARP versus LRP

Figure 21, urinary continence at 3 months

Study or sub-category	Robotic surgery n/N	Laparoscopic surgery n/N	Weight %	RR (random) 95% CI
Joseph	45/50	46/50	42.30	0.98 [0.86, 1.11]
Ball	48/82	66/124	28.44	1.10 [0.86, 1.41]
Trabulsi 2	164/205	28/45	29.27	1.29 [1.01, 1.63]
Total (95% CI)	337	219	100.00	1.10 [0.90, 1.34]

Total events: 257 (Robotic surgery), 140 (Laparoscopic surgery)
Test for heterogeneity: Chi² = 5.95, df = 2 (P = 0.05), I² = 66.4%
Test for overall effect: Z = 0.90 (P = 0.37)

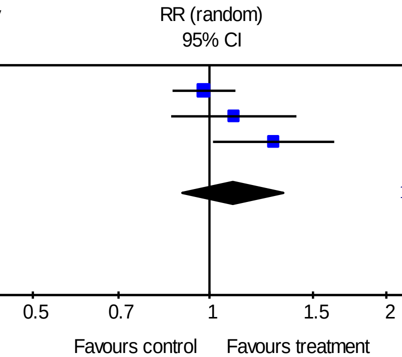
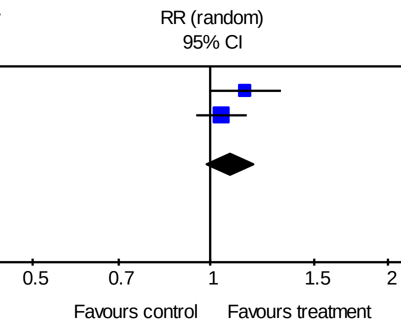


Figure 22, urinary continence at 12 months

Study or sub-category	Robotic surgery n/N	Laparoscopic surgery n/N	Weight %	RR (random) 95% CI
Trabulsi 2	193/205	37/45	36.21	1.15 [1.00, 1.32]
Hakimi	70/75	67/75	63.79	1.04 [0.95, 1.15]
Total (95% CI)	280	120	100.00	1.08 [0.99, 1.18]

Total events: 263 (Robotic surgery), 104 (Laparoscopic surgery)
Test for heterogeneity: Chi² = 1.21, df = 1 (P = 0.27), I² = 17.7%
Test for overall effect: Z = 1.66 (P = 0.10)



CI = confidence interval; LRP = laparoscopic radical prostatectomy; n/N = number of events/sample population; RARP = robot-assisted radical prostatectomy; RR = risk ratio; SD = standard deviation; WMD = weighted mean difference.

As seen in the comparison of RARP with ORP (section 4.2.3.1.1), many of the meta-analyses performed in this section to compare RARP with LRP were associated with I^2 and chi^2 values that indicated the presence of statistically significant heterogeneity. Efforts were made to assess information that was collected from included studies and considered to be relevant potential sources of heterogeneity, to investigate whether any were correlated with study outcomes. Subgroup and sensitivity analyses based on study design (prospective compared with retrospective), study quality (high or good, compared with remaining scores), and removal of outliers were explored using forest plots to identify systematic variations. Appendix 9 presents the findings of subgroup analyses based on study design (Table A10), study quality (Table A11), and removal of outliers (Table A12). For some outcomes, conventional measures of statistical heterogeneity suggested less variation between study-level estimates when data were grouped based on study quality. For many outcomes, there were no obvious outliers.

4.2.3.2 Hysterectomy

4.2.3.2.1 Robot-assisted radical hysterectomy–robot-assisted total hysterectomy compared with open radical hysterectomy–open total hysterectomy

Table 7 summarizes the amount of data available for each clinical outcome and the pooled findings from all meta-analyses, as well as the associated measures of heterogeneity. Summary meta-analysis plots corresponding to these analyses are shown in Figures 23 to 27 (Table 8) to allow for inspection of between-study heterogeneity. Sensitivity and subgroup analyses are discussed after the presentation of preliminary findings.

Based on a review of results that were obtained from meta-analysis:

- Robot-assisted radical hysterectomy–robot-assisted total hysterectomy (RARH-RATH) was associated with a statistically significantly longer operative duration relative to open radical hysterectomy–open total hysterectomy (ORH-OTH; WMD 63.57 minutes, 95% CI 40.91 minutes to 86.22 minutes). Of the 16 included studies, 13 were associated with statistically significant effects favouring ORH-OTH, one favoured RARH-RATH, and two were inconclusive.
- RARH-RATH was associated with a statistically significantly shorter length of hospital stay relative to ORH-OTH (WMD −2.60 days, 95% CI −2.99 to −2.21 days). All 15 included studies favoured RARH-RATH and were associated with statistically significant differences.
- RARH-RATH was associated with fewer complications compared with ORH-OTH (RR 0.38, 95% CI 0.27 to 0.52). The point estimates from all studies favoured RARH-RATH, and eight studies were associated with statistically significant differences. The most commonly reported complications were ileus, wound infection, lymphedema, vaginal cuff hernia, port site hernia, re-operation for bleeding, delayed voiding, deep vein thrombosis, and vaginal cuff dehiscence.
- RARH-RATH was associated with a statistically significant reduction in the extent of blood loss compared with ORH-OTH (−222.03 mL, 95% CI −270.84 mL to −173.22 mL). All 14 of the included studies showed statistically significant results favouring RARH-RATH. RARH-RATH was also associated with a reduced risk of transfusion (RR 0.25, 95% CI 0.15 to 0.41).

Table 7: Primary Findings from Meta-analysis, Hysterectomy, RARH-RATH Compared with ORH-OTH				
Outcome Measure	**Number of Studies**	**Total Sample Size**	**Statistical Heterogeneity Measures: I^2, P-Value**	**Pooled Estimate (95% CI)**
Operative time (minutes)	16	1,561	95.7%, < 0.00001	63.57 [40.91, 86.22]
Hospital stay (days)	15	1,335	88.6%, < 0.00001	−2.60 [−2.99, −2.21]
Incidence of complications	14	1,345	34.7%, 0.10	0.38 [0.27, 0.52]
Blood loss (mL)	14	1,450	89.6%, < 0.00001	−222.03 [−270.84, −173.22]
Incidence of transfusion	11	1,025	0%, 0.96	0.25 [0.15, 0.41]

CI = confidence interval; ORH = open radical hysterectomy; OTH = open total hysterectomy; RARH = robot-assisted radical hysterectomy; RATH = robot-assisted total hysterectomy; RR = risk ratio; WMD = weighted mean difference.

Pooled estimates are reported as WMD for continuous measures and as RR for dichotomous measures. For continuous outcomes, a difference < 0 favours RARH-RATH.

Table 8: Hysterectomy Meta-analyses, RARH-RATH Compared with ORH-OTH

Figure 23, operative time

Study or sub-category	Robotic surgery N	Robotic surgery Mean (SD)	Open surgery N	Open surgery Mean (SD)	Weight %	WMD (random) 95% CI
Bell	40	184.00(41.30)	40	108.60(41.40)	6.50	75.40 [57.28, 93.52]
Boggess	103	191.20(36.00)	138	146.50(48.80)	6.68	44.70 [33.99, 55.41]
Boggess 2	51	210.90(45.50)	49	247.80(48.80)	6.48	-36.90 [-55.41, -18.39]
DeNardis	56	177.00(55.00)	106	79.00(17.00)	6.59	98.00 [83.24, 112.76]
Ko	16	290.00(49.30)	32	219.00(54.75)	6.03	71.00 [40.29, 101.71]
Veljovich	25	283.00(48.11)	131	139.00(34.75)	6.44	144.00 [124.22, 163.78]
Estape	32	144.00(48.00)	14	114.00(36.00)	6.26	30.00 [4.86, 55.14]
Feuer	32	122.10(33.00)	20	67.50(16.20)	6.62	54.60 [41.14, 68.06]
Maggioni	40	272.27(42.30)	40	199.60(65.60)	6.29	72.67 [48.48, 96.86]
Seamon 2	92	228.00(43.00)	162	143.00(47.00)	6.66	85.00 [73.62, 96.38]
Geisler	30	154.00(26.18)	30	166.00(41.50)	6.51	-12.00 [-29.56, 5.56]
Gocmen	10	234.60(58.70)	12	168.50(42.10)	5.42	66.10 [22.61, 109.59]
Halliday	16	351.00(51.00)	24	283.00(63.00)	5.81	68.00 [32.51, 103.49]
Jung	28	193.18(60.42)	56	187.85(76.55)	6.06	5.33 [-24.72, 35.38]
Nevadunsky	66	204.00(51.00)	43	134.00(36.20)	6.55	70.00 [53.62, 86.38]
Schreuder	13	434.00(73.78)	14	225.00(56.25)	5.11	209.00 [159.23, 258.77]
Total (95% CI)	650		911		100.00	63.57 [40.91, 86.22]

Test for heterogeneity: Chi² = 350.23, df = 15 (P < 0.00001), I² = 95.7%
Test for overall effect: Z = 5.50 (P < 0.00001)

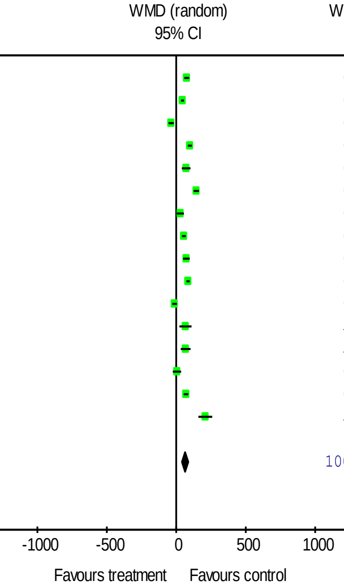


Figure 24, hospital stay

Study or sub-category	Robotic surgery N	Robotic surgery Mean (SD)	Open surgery N	Open surgery Mean (SD)	Weight %	WMD (random) 95% CI
Bell	40	2.30(1.30)	40	4.00(1.50)	7.75	-1.70 [-2.32, -1.08]
Boggess	103	1.00(0.20)	138	4.40(2.00)	8.98	-3.40 [-3.74, -3.06]
Boggess 2	51	1.00(0.57)	49	3.20(1.38)	8.66	-2.20 [-2.62, -1.78]
DeNardis	56	1.00(0.50)	106	3.20(1.20)	9.21	-2.20 [-2.46, -1.94]
Ko	16	1.70(0.97)	32	4.90(2.11)	6.48	-3.20 [-4.07, -2.33]
Estape	32	2.60(2.10)	14	4.00(1.70)	5.22	-1.40 [-2.55, -0.25]
Feuer	32	1.70(1.10)	20	5.20(1.50)	7.04	-3.50 [-4.26, -2.74]
Lowe	7	1.00(0.17)	7	5.00(1.25)	6.18	-4.00 [-4.93, -3.07]
Maggioni	40	3.70(1.20)	40	5.00(2.40)	6.68	-1.30 [-2.13, -0.47]
Seamon 2	92	1.00(0.57)	162	3.00(1.29)	9.31	-2.00 [-2.23, -1.77]
Geisler	30	1.40(0.80)	30	2.80(1.20)	8.23	-1.40 [-1.92, -0.88]
Gocmen	10	2.80(0.98)	12	8.80(3.70)	2.39	-6.00 [-8.18, -3.82]
Halliday	16	1.90(0.90)	24	7.20(5.30)	2.41	-5.30 [-7.47, -3.13]
Nevadunsky	66	1.30(0.46)	43	3.80(0.60)	9.35	-2.50 [-2.71, -2.29]
Schreuder	13	4.00(2.28)	14	9.00(3.87)	2.10	-5.00 [-7.38, -2.62]
Total (95% CI)	604		731		100.00	-2.60 [-2.99, -2.21]

Test for heterogeneity: Chi² = 122.99, df = 14 (P < 0.00001), I² = 88.6%
Test for overall effect: Z = 13.12 (P < 0.00001)

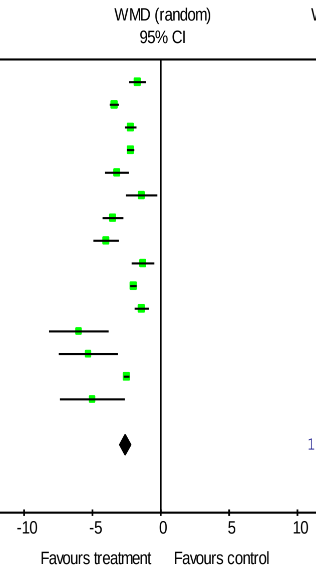


Table 8: Hysterectomy Meta-analyses, RARH-RATH Compared with ORH-OTH

Figure 25, complication rate

Study or sub-category	Robotic surgery n/N	Open surgery n/N	Weight %	RR (random) 95% CI
Bell	3/40	11/40	5.70	0.27 [0.08, 0.90]
Boggess	6/103	41/138	9.60	0.20 [0.09, 0.44]
Boggess 2	4/51	8/49	6.19	0.48 [0.15, 1.49]
DeNardis	5/56	48/106	9.00	0.20 [0.08, 0.47]
Ko	2/16	7/32	4.20	0.57 [0.13, 2.44]
Estape	6/32	4/14	6.49	0.66 [0.22, 1.97]
Feuer	7/32	6/20	8.10	0.73 [0.29, 1.86]
Maggioni	19/40	30/40	18.21	0.63 [0.44, 0.92]
Seamon 2	10/92	44/162	12.54	0.40 [0.21, 0.76]
Gocmen	1/10	4/12	2.37	0.30 [0.04, 2.27]
Halliday	3/16	17/24	6.91	0.26 [0.09, 0.76]
Jung	2/28	14/56	4.41	0.29 [0.07, 1.17]
Nevadunsky	2/66	10/43	4.13	0.13 [0.03, 0.57]
Schreuder	1/13	3/14	2.15	0.36 [0.04, 3.03]
Total (95% CI)	595	750	100.00	0.38 [0.27, 0.52]

Total events: 71 (Robotic surgery), 247 (Open surgery)
Test for heterogeneity: Chi² = 19.90, df = 13 (P = 0.10), I² = 34.7%
Test for overall effect: Z = 5.84 (P < 0.00001)

RR (random) 95% CI

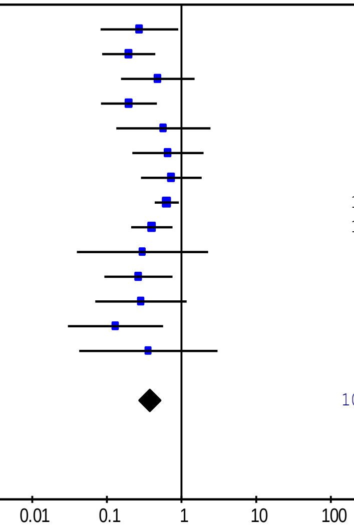


Figure 26, blood loss

Review: Surgical Robotics
Comparison: 02 Hysterectomy
Outcome: 17 Blood loss - Robot (all) vs Open (all)

Study or sub-category	Robotic surgery N	Robotic surgery Mean (SD)	Open surgery N	Open surgery Mean (SD)	Weight %	WMD (random) 95% CI
Bell	40	166.00(225.90)	40	316.00(282.00)	6.24	-150.00 [-261.97, -38.03]
Boggess	103	74.50(101.00)	138	266.00(184.50)	8.83	-191.50 [-227.94, -155.06]
Boggess 2	51	96.50(85.80)	49	416.80(188.00)	8.22	-320.30 [-377.97, -262.63]
DeNardis	56	105.00(77.00)	106	241.00(115.00)	8.98	-136.00 [-165.77, -106.23]
Ko	16	81.90(88.40)	32	665.60(399.00)	5.11	-583.70 [-728.57, -438.83]
Veljovich	25	66.60(72.00)	131	197.60(119.00)	8.87	-131.00 [-165.81, -96.19]
Estape	32	130.00(119.00)	14	621.40(294.00)	4.67	-491.40 [-650.83, -331.97]
Feuer	32	99.20(46.20)	20	275.00(206.00)	7.00	-175.80 [-267.49, -84.11]
Maggioni	40	78.00(94.80)	40	221.80(132.40)	8.45	-143.80 [-194.26, -93.34]
Seamon 2	92	109.00(118.00)	162	394.00(236.00)	8.65	-285.00 [-328.61, -241.39]
Geisler	30	165.00(178.20)	30	323.00(193.80)	6.90	-158.00 [-252.21, -63.79]
Gocmen	10	95.00(102.60)	12	255.00(153.00)	6.41	-160.00 [-267.41, -52.59]
Halliday	16	106.00(113.00)	24	546.00(570.00)	2.95	-440.00 [-674.67, -205.33]
Nevadunsky	66	83.00(89.60)	43	193.00(115.80)	8.72	-110.00 [-150.81, -69.19]
Total (95% CI)	609		841		100.00	-222.03 [-270.84, -173.22]

Test for heterogeneity: Chi² = 124.41, df = 13 (P < 0.00001), I² = 89.6%
Test for overall effect: Z = 8.92 (P < 0.00001)

WMD (random) 95% CI

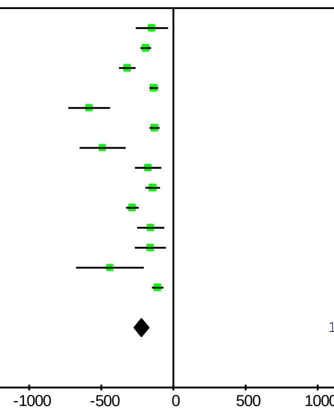
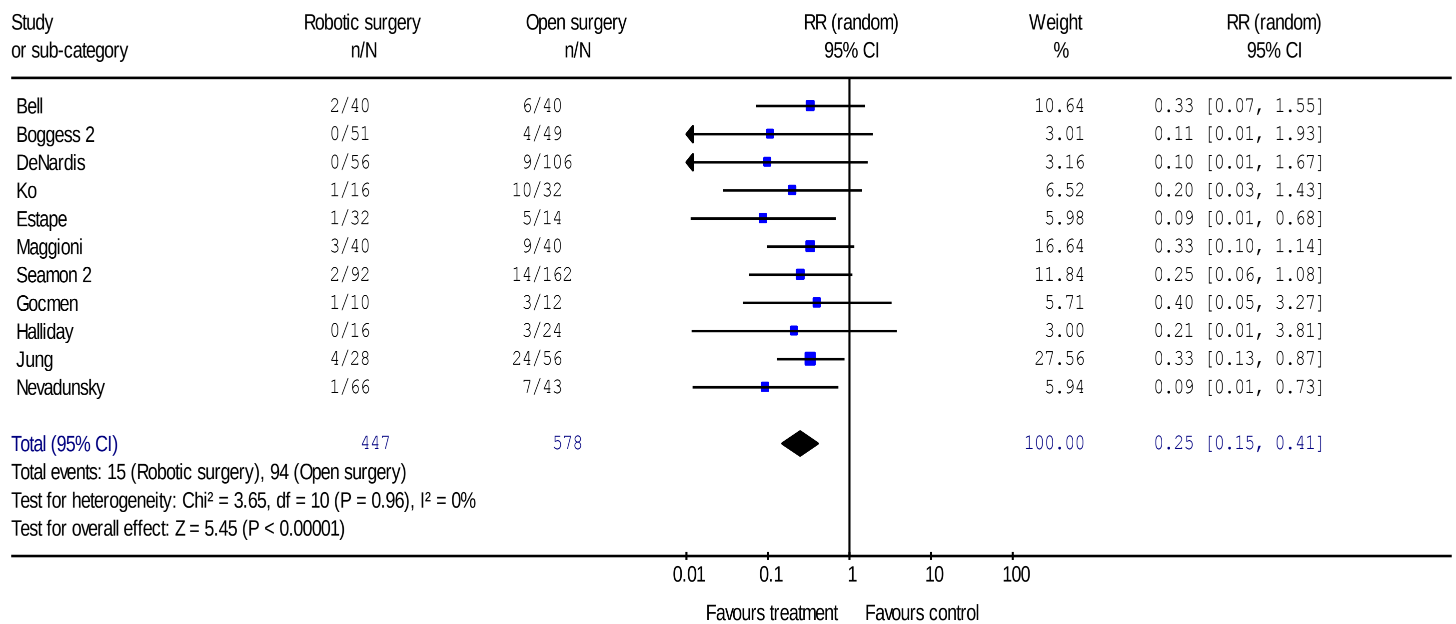


Table 8: Hysterectomy Meta-analyses, RARH-RATH Compared with ORH-OTH

Figure 27, incidence of transfusion



CI = confidence interval; n/N = number of events/sample population; ORH = open radical hysterectomy; OTH = open total hysterectomy; RARH = robot-assisted radical hysterectomy; RATH = robot-assisted total hysterectomy; RR = risk ratio; SD = standard deviation; WMD = weighted mean difference

Subgroup and sensitivity analyses based on study design (prospective compared with retrospective), study quality (high or good, compared with remaining scores), and removal of outliers were explored using forest plots to identify systematic variations of findings in the meta-analyses done to compare RARH-RATH with ORH-OTH. Appendix 10 presents the findings of the analyses based on study design (Table A13), study quality (Table A14), and removal of outliers (Table A15). These analyses did not provide additional insight into variations in outcomes across studies. Information about surgeons' experience was insufficient to perform a sensitivity analysis of the impact of the learning curve on clinical outcomes.

4.2.3.2.2 Robot-assisted radical hysterectomy–robot-assisted total hysterectomy compared with laparoscopic radical hysterectomy–laparoscopic total hysterectomy

Table 9 summarizes the data available for each clinical outcome and the pooled findings from all meta-analyses, as well as the associated measures of heterogeneity. Summary meta-analysis plots corresponding to these analyses are presented in Figures 28 to 32 (Table 10) to allow for inspection of between-study heterogeneity. Sensitivity and subgroup analyses are discussed after the presentation of preliminary findings.

Based on a review of results that were obtained from meta-analysis:

- For operative duration, there is a high degree of heterogeneity among study findings, and thus a meta-analysis was not performed. Four of the 13 included studies were associated with statistically significant effects favouring RARH-RATH, five favoured laparoscopic radical hysterectomy–laparoscopic total hysterectomy (LRH-LTH), and four were inconclusive. Figure 28 in Table 10 summarizes all study findings.
- RARH-RATH was associated with a statistically significantly shorter length of hospital stay relative to LRH-LTH (WMD −0.22 days, 95% CI −0.38 days to −0.06 days). Five of 11 included studies favoured RARH-RATH and were associated with statistically significant differences, and six were associated with inconclusive results.
- RARH-RATH was associated with a statistically significant reduction in complications compared with LRH-LTH (RR 0.54, 95% CI 0.31 to 0.95). The point estimates from all five studies favoured RARH-RATH. The most commonly reported complications were wound infection, ileus, lymphedema, vaginal cuff hematoma, bleeding, delayed voiding, deep vein thrombosis, and injury of vena cava.
- RARH-RATH was associated with a statistically significant reduction in the extent of blood loss compared with LRH-LTH (−60.96 mL, 95% CI −78.37 mL to −43.54 mL). Of the 11 included studies, 10 were associated with point estimates favouring RARH-RATH, and five of these studies reported statistically significant differences. A comparison of the risk of transfusion exposure was found to be inconclusive (RR 0.62, 95% CI 0.26 to 1.49); one study indicated a statistically significant difference favouring RARH-RATH, and the remaining four studies reported inconclusive results.

Table 9: Primary Findings from Meta-analysis, Hysterectomy, RARH-RATH Compared with LRH-LTH				
Outcome Measure	**Number of Studies**	**Total Sample Size**	**Statistical Heterogeneity Measures: I^2, P-Value**	**Pooled Estimate (95% CI)**
Operative time (minutes)	13	1,314	94.6%, < 0.00001	11.46 [−7.95, 30.87]
Hospital stay (days)	11	1,080	63.4%, 0.002	−0.22 [−0.38, −0.06]
Incidence of complications	5	389	0%, 0.62	0.54 [0.31, 0.95]
Blood loss (mL)	11	1,080	17.6%, 0.28	–60.96 [−78.37, −43.54]
Incidence of transfusion	5	595	33.1%, 0.20	0.62 [0.26, 1.49]

CI = confidence interval; LRH = laparoscopic radical hysterectomy; LTH = laparoscopic total hysterectomy; RARH = robot-assisted radical hysterectomy; RATH = robot-assisted total hysterectomy; RR = risk ratio; WMD = weighted mean difference.

Pooled estimates are reported as WMD for continuous measures and as RR for dichotomous measures. For continuous outcomes, a difference < 0 favours RARH-RATH.

Table 10: Hysterectomy Meta-analyses, RARH-RATH Compared with LRH-LTH

Figure 28, operative time

Review: Surgical Robotics
Comparison: 02 Hysterectomy
Outcome: 11 Operative time - Robot (all) vs Laparoscopic surgery (all)

Study or sub-category	Robotic surgery N	Robotic surgery Mean (SD)	Laparoscopic surgery N	Laparoscopic surgery Mean (SD)	Weight %	WMD (random) 95% CI
Sert	7	241.00(40.97)	8	300.00(42.00)	6.14	-59.00 [-101.05, -16.95]
Bell	40	184.00(41.30)	30	171.20(36.20)	8.02	12.80 [-5.41, 31.01]
Boggess	103	191.20(36.00)	81	213.40(34.70)	8.43	-22.20 [-32.47, -11.93]
Gehrig	49	189.00(47.25)	32	215.00(34.40)	8.05	-26.00 [-43.81, -8.19]
Payne	100	119.40(29.85)	100	92.40(14.78)	8.55	27.00 [20.47, 33.53]
Veljovich	25	283.00(48.11)	4	255.00(35.70)	6.34	28.00 [-11.74, 67.74]
Estape	32	144.00(48.00)	17	132.00(42.00)	7.47	12.00 [-13.98, 37.98]
Nezhat	26	276.00(46.92)	50	206.00(28.84)	7.92	70.00 [50.27, 89.73]
Seamon	105	242.00(53.00)	76	287.00(55.00)	8.15	-45.00 [-60.99, -29.01]
Shashoua	24	142.20(35.55)	44	122.10(19.53)	8.19	20.10 [4.75, 35.45]
Cardenas-Goicoechea	102	237.00(57.00)	173	178.00(58.90)	8.25	59.00 [44.88, 73.12]
Holtz	13	192.50(38.00)	20	156.20(49.00)	7.17	36.30 [6.50, 66.10]
Jung	28	193.18(60.42)	25	165.20(43.39)	7.31	27.98 [-0.13, 56.09]

WMD (random) 95% CI

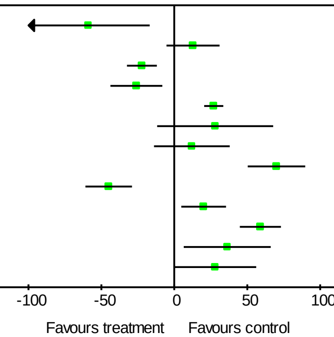


Figure 29, hospital stay

Study or sub-category	Robotic surgery N	Robotic surgery Mean (SD)	Laparoscopic surgery N	Laparoscopic surgery Mean (SD)	Weight %	WMD (random) 95% CI
Sert	7	4.00(2.28)	8	8.00(4.80)	0.18	-4.00 [-7.73, -0.27]
Bell	40	2.30(1.30)	30	2.00(1.20)	5.30	0.30 [-0.29, 0.89]
Boggess	103	1.00(0.20)	81	1.20(0.50)	18.19	-0.20 [-0.32, -0.08]
Gehrig	49	1.02(0.36)	32	1.27(0.53)	14.87	-0.25 [-0.46, -0.04]
Payne	100	1.10(0.39)	100	1.60(0.67)	16.98	-0.50 [-0.65, -0.35]
Veljovich	25	1.70(0.97)	4	1.20(0.72)	3.25	0.50 [-0.30, 1.30]
Estape	32	2.60(2.10)	17	2.30(1.40)	2.27	0.30 [-0.69, 1.29]
Nezhat	26	1.00(0.57)	50	1.05(0.63)	12.32	-0.05 [-0.33, 0.23]
Shashoua	24	1.00(0.35)	44	1.40(0.59)	14.35	-0.40 [-0.62, -0.18]
Cardenas-Goicoechea	102	1.88(1.67)	173	2.31(2.21)	7.39	-0.43 [-0.89, 0.03]
Holtz	13	1.70(0.60)	20	1.70(1.20)	4.92	0.00 [-0.62, 0.62]
Total (95% CI)	521		559		100.00	-0.22 [-0.38, -0.06]

Test for heterogeneity: Chi² = 27.36, df = 10 (P = 0.002), I² = 63.4%
Test for overall effect: Z = 2.76 (P = 0.006)

WMD (random) 95% CI

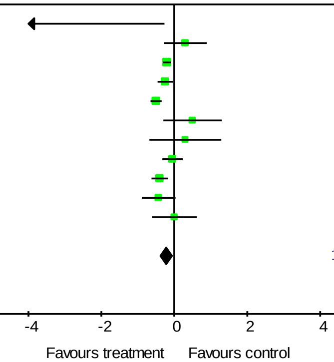


Table 10: Hysterectomy Meta-analyses, RARH-RATH Compared with LRH-LTH

Figure 30, complication rate

Study or sub-category	Robotic surgery n/N	Laparoscopic surgery n/N	Weight %	RR (random) 95% CI
Bell	3/40	8/30	20.32	0.28 [0.08, 0.97]
Boggess	6/103	11/81	34.50	0.43 [0.17, 1.11]
Estape	6/32	4/17	24.88	0.80 [0.26, 2.44]
Holtz	2/13	3/20	11.50	1.03 [0.20, 5.33]
Jung	2/28	2/25	8.79	0.89 [0.14, 5.88]
Total (95% CI)	216	173	100.00	0.54 [0.31, 0.95]

Total events: 19 (Robotic surgery), 28 (Laparoscopic surgery)
Test for heterogeneity: Chi² = 2.62, df = 4 (P = 0.62), I² = 0%
Test for overall effect: Z = 2.15 (P = 0.03)

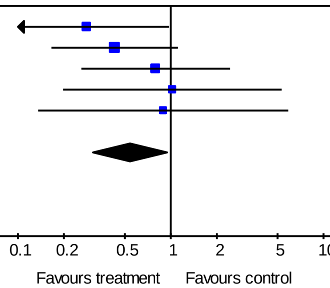


Figure 31, blood loss

Study or sub-category	Robotic surgery N	Robotic surgery Mean (SD)	Laparoscopic surgery N	Laparoscopic surgery Mean (SD)	Weight %	WMD (random) 95% CI
Sert	7	71.00(77.00)	8	160.00(173.00)	1.67	-89.00 [-221.76, 43.76]
Bell	40	166.00(225.90)	30	253.00(427.70)	1.05	-87.00 [-255.30, 81.30]
Boggess	103	74.50(101.20)	81	145.80(105.60)	20.78	-71.30 [-101.48, -41.12]
Gehrig	49	50.00(54.00)	32	150.00(162.00)	7.72	-100.00 [-158.13, -41.87]
Payne	100	61.10(66.00)	100	113.00(122.00)	23.55	-51.90 [-79.09, -24.71]
Veljovich	25	66.60(72.00)	4	75.00(81.00)	3.97	-8.40 [-92.65, 75.85]
Estape	32	130.00(119.40)	17	209.40(169.90)	3.45	-79.40 [-170.14, 11.34]
Nezhat	26	250.00(270.00)	50	300.00(324.00)	1.56	-50.00 [-187.24, 87.24]
Shashoua	24	113.50(122.00)	44	98.90(107.00)	7.72	14.60 [-43.55, 72.75]
Cardenas-Goicoechea	102	109.00(83.30)	173	187.00(187.00)	19.11	-78.00 [-110.22, -45.78]
Holtz	13	84.60(32.00)	20	150.00(111.00)	9.42	-65.40 [-117.06, -13.74]
Total (95% CI)	521		559		100.00	-60.96 [-78.37, -43.54]

Test for heterogeneity: Chi² = 12.13, df = 10 (P = 0.28), I² = 17.6%
Test for overall effect: Z = 6.86 (P < 0.00001)

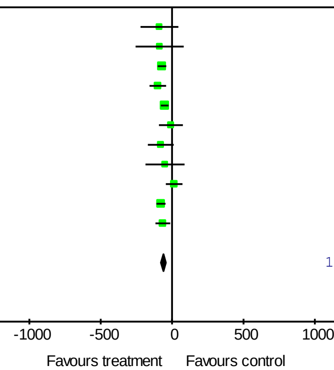
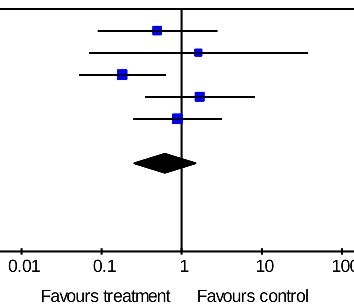


Figure 32, incidence of transfusion

Study or sub-category	Robotic surgery n/N	Laparoscopic surgery n/N	Weight %	RR (random) 95% CI
Bell	2/40	3/30	18.25	0.50 [0.09, 2.81]
Estape	1/32	0/17	6.91	1.64 [0.07, 38.14]
Seamon	3/92	10/56	27.50	0.18 [0.05, 0.64]
Cardenas-Goicoechea	3/102	3/173	20.56	1.70 [0.35, 8.25]
Jung	4/28	4/25	26.78	0.89 [0.25, 3.20]
Total (95% CI)	294	301	100.00	0.62 [0.26, 1.49]

Total events: 13 (Robotic surgery), 20 (Laparoscopic surgery)
Test for heterogeneity: Chi² = 5.98, df = 4 (P = 0.20), I² = 33.1%
Test for overall effect: Z = 1.07 (P = 0.28)



CI = confidence interval; LRH = laparoscopic radical hysterectomy; LTH = laparoscopic total hysterectomy; n/N = number of events/sample population; RARH = robot-assisted radical hysterectomy; RATH = robot-assisted total hysterectomy; RR = risk ratio; SD = standard deviation; WMD = weighted mean difference.

Subgroup and sensitivity analyses based on study design (prospective compared with retrospective), study quality (high or good, compared with remaining scores), and removal of outliers were explored using forest plots to identify systematic variations of the meta-analyses done to compare RARH-RATH with LRH-LTH. Appendix 10 presents the findings of the analyses based on study design (Table A13), study quality (Table A14), and removal of outliers (Table A15). These analyses did not provide additional insight into variations in findings across studies. Information about surgeons' experience was insufficient to perform a sensitivity analysis exploring the impact of the learning curve on clinical outcomes.

4.2.3.3 Nephrectomy

4.2.3.3.1 Robot-assisted partial nephrectomy compared with laparoscopic partial nephrectomy

Table 11 summarizes the data available for each clinical outcome and the pooled findings from all meta-analyses, as well as the associated measures of heterogeneity. Summary meta-analysis plots corresponding to these analyses are shown in Figures 33 to 38 (Table 12) to allow for the inspection of between-study heterogeneity. Sensitivity and subgroup analyses are discussed after the presentation of preliminary findings.

Based on results from meta-analysis:

- For operative duration, there is a high degree of heterogeneity among studies, and thus meta-analysis was not performed. Three of the eight included studies were associated with statistically significant effects favouring robot-assisted partial nephrectomy (RAPN), three favoured laparoscopic partial nephrectomy (LPN), and two were inconclusive. Figure 33 in Table 12 summarizes all study findings.
- RAPN was associated with a statistically significant reduction in length of hospital stay relative to LPN (WMD −0.25 days, 95% CI −0.47 days to −0.03 days). Three of eight included studies favoured RAPN and were associated with statistically significant differences, and five studies were associated with inconclusive results.
- For complication rates, a comparison of RAPN with LPN did not show a difference between treatments (RR 1.24, 95% CI 0.79 to 1.93). All five studies reported inconclusive comparisons. The most commonly reported complications were urinary leaks, bleeding, hematoma, and pulmonary emboli.
- RAPN was associated with a non-statistically significant reduction in the extent of blood loss compared with LPN (−17.44 mL, 95% CI −53.63 to 18.75 mL). Two studies (Aron[106] and Haber[110]) reported an increase in blood loss associated with RAPN compared with LPN. The removal of these two studies in the meta-analysis yielded a statistically significant reduction in the extent of blood loss (−31.49 mL, 95% CI −49.58 to −13.41 mL) with no heterogeneity (P_{heter} = 0.40). A comparison of the relative risk of transfusion was found to be inconclusive (RR 0.85, 95% CI 0.24 to 3.09); all studies reported inconclusive results.
- For warm ischemic time, the pooled estimate was statistically significant, favouring RAPN (WMD −4.18 minutes, 95% CI −8.17 to −0.18 minutes). Six of eight studies favoured RAPN, two of which reported a statistically significant result.

Table 11: Primary Findings from Meta-analysis, Nephrectomy, RAPN Compared with LPN				
Outcome Measure	**Number of Studies**	**Total Sample Size**	**Statistical Heterogeneity Measures: I^2, P-value**	**Pooled Estimate (95% CI)**
Operative time (minutes)	9	717	84.6%, < 0.00001	1.42 [−15,78, 18.62]
Hospital stay (days)	9	717	79.5%, < 0.00001	−0.25 [−0.47, −0.03]
Incidence of complications	6	611	1.3%, 0.92	1.24 [0.79, 1.93]
Blood loss (mL)	9	717	71.4%, 0.0004	−17.44 [−53.63, 18.75]
Incidence of transfusion	4	434	0%, 0.62	0.85 (0.24, 3.09)
Warm ischemic time (min)	8	658	80.6%, < 0.00001	−4.18 [−8.17, −0.18]

CI = confidence interval; LPN = laparoscopic partial nephrectomy; RAPN = robot-assisted partial nephrectomy; RR = risk ratio; WMD = weighted mean difference.

Pooled estimates are reported as WMD for continuous measures and as RR for dichotomous measures. For continuous outcomes, a difference < 0 favours RAPN.

Table 12: Nephrectomy Meta-analyses, RAPN versus LPN

Figure 33, operative time

Review: Surgical Robotics
Comparison: 03 Nephrectomy
Outcome: 01 Operative time - Robot vs Laparoscopic surgery

Study or sub-category	Robotic surgery N	Robotic surgery Mean (SD)	Laparoscopic surgery N	Laparoscopic surgery Mean (SD)	Weight %	WMD (random) 95% CI
Aron	12	242.00(69.20)	12	256.00(70.60)	5.89	-14.00 [-69.93, 41.93]
Deane	11	228.00(41.10)	11	289.50(72.30)	6.87	-61.50 [-110.65, -12.35]
Benway	129	189.00(34.00)	118	174.00(43.50)	14.88	15.00 [5.20, 24.80]
Jeong	31	169.90(30.60)	23	139.00(34.70)	13.39	30.90 [13.09, 48.71]
Kural	11	185.00(33.30)	20	226.00(56.50)	10.23	-41.00 [-72.63, -9.37]
Wang	40	140.00(25.20)	62	156.00(39.00)	14.45	-16.00 [-28.46, -3.54]
Boger	13	168.00(30.24)	46	171.00(42.75)	12.78	-3.00 [-23.56, 17.56]
DeLong	13	344.00(61.90)	15	254.00(63.50)	7.29	90.00 [43.47, 136.53]
Haber	75	200.00(36.00)	75	197.00(49.25)	14.21	3.00 [-10.81, 16.81]

WMD (random) 95% CI

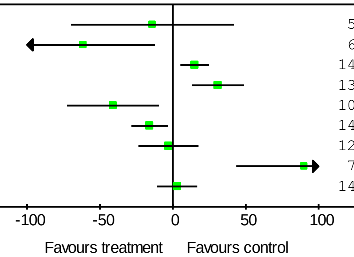


Figure 34, hospital stay

Review: Surgical Robotics
Comparison: 03 Nephrectomy
Outcome: 02 Length of stay - Robot vs Laparoscopic surgery

Study or sub-category	Robotic surgery N	Robotic surgery Mean (SD)	Laparoscopic surgery N	Laparoscopic surgery Mean (SD)	Weight %	WMD (random) 95% CI
Aron	12	4.70(2.40)	12	4.40(1.10)	1.87	0.30 [-1.19, 1.79]
Deane	11	2.00(0.48)	11	3.10(0.37)	11.56	-1.10 [-1.46, -0.74]
Benway	129	2.40(0.57)	118	2.70(0.32)	16.14	-0.30 [-0.41, -0.19]
Jeong	31	5.20(1.24)	23	5.30(0.63)	8.79	-0.10 [-0.61, 0.41]
Kural	11	3.90(0.70)	20	4.27(1.12)	6.81	-0.37 [-1.01, 0.27]
Wang	40	2.50(0.60)	62	2.90(0.35)	14.67	-0.40 [-0.61, -0.19]
Boger	13	2.00(0.48)	46	2.00(0.24)	13.39	0.00 [-0.27, 0.27]
DeLong	13	2.00(0.48)	15	2.00(0.24)	13.02	0.00 [-0.29, 0.29]
Haber	75	4.20(1.00)	75	4.10(0.49)	13.75	0.10 [-0.15, 0.35]
Total (95% CI)	335		382		100.00	-0.25 [-0.47, -0.03]

Test for heterogeneity: Chi² = 38.96, df = 8 (P < 0.00001), I² = 79.5%
Test for overall effect: Z = 2.25 (P = 0.02)

WMD (random) 95% CI

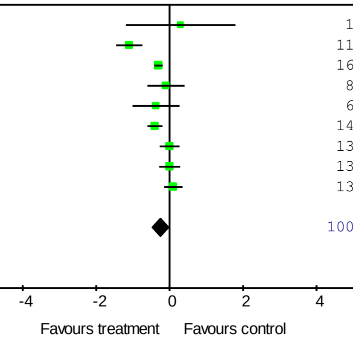


Table 12: Nephrectomy Meta-analyses, RAPN versus LPN

Figure 35, complication rate

Review: Surgical Robotics
Comparison: 03 Nephrectomy
Outcome: 03 Peri-op complications - Robot vs Laparoscopic surgery

Study or sub-category	Robotic surgery n/N	Laparoscopic surgery n/N	Weight %	RR (random) 95% CI
Deane	1/11	0/11	2.05	3.00 [0.14, 66.53]
Benway	11/129	12/118	31.62	0.84 [0.38, 1.83]
Kural	1/11	2/20	3.77	0.91 [0.09, 8.93]
Wang	6/40	8/62	20.15	1.16 [0.44, 3.10]
Boger	4/13	3/46	10.51	4.72 [1.21, 18.46]
Haber	12/75	10/75	31.89	1.20 [0.55, 2.61]
Total (95% CI)	279	332	100.00	1.24 [0.79, 1.93]

Total events: 35 (Robotic surgery), 35 (Laparoscopic surgery)
Test for heterogeneity: Chi² = 5.07, df = 5 (P = 0.41), I² = 1.3%
Test for overall effect: Z = 0.95 (P = 0.34)

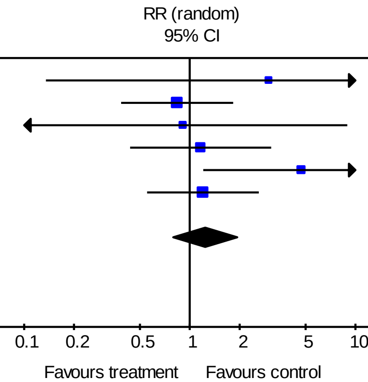


Figure 36, blood loss

Review: Surgical Robotics
Comparison: 03 Nephrectomy
Outcome: 05 Blood loss - Robot vs Laparoscopic surgery

Study or sub-category	Robotic surgery N	Robotic surgery Mean (SD)	Laparoscopic surgery N	Laparoscopic surgery Mean (SD)	Weight %	WMD (random) 95% CI
Aron	12	329.00 (315.00)	12	300.00 (384.00)	1.53	29.00 [-252.01, 310.01]
Deane	11	115.00 (60.90)	11	198.00 (142.50)	8.58	-83.00 [-174.58, 8.58]
Benway	129	155.00 (82.15)	118	196.00 (141.00)	16.94	-41.00 [-70.12, -11.88]
Jeong	31	198.30 (105.00)	23	208.30 (146.70)	11.06	-10.00 [-80.43, 60.43]
Kural	11	286.40 (151.70)	20	387.50 (279.00)	4.38	-101.10 [-252.72, 50.52]
Wang	40	136.00 (72.00)	62	173.00 (124.50)	15.70	-37.00 [-75.19, 1.19]
Boger	13	100.00 (53.00)	46	100.00 (72.00)	16.08	0.00 [-35.54, 35.54]
DeLong	13	100.00 (53.00)	15	150.00 (108.00)	12.24	-50.00 [-111.78, 11.78]
Haber	75	323.00 (171.20)	75	222.00 (159.84)	13.51	101.00 [47.99, 154.01]
Total (95% CI)	335		382		100.00	-17.44 [-53.63, 18.75]

Test for heterogeneity: Chi² = 27.97, df = 8 (P = 0.0005), I² = 71.4%
Test for overall effect: Z = 0.94 (P = 0.34)

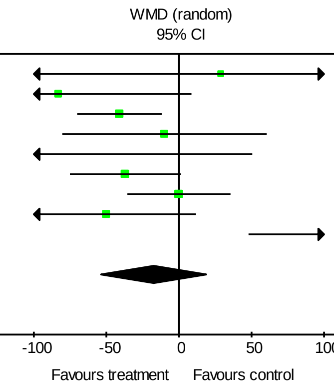


Table 12: Nephrectomy Meta-analyses, RAPN versus LPN

Figure 37, incidence of transfusion

Review: Surgical Robotics
Comparison: 03 Nephrectomy
Outcome: 04 Rate of transfusion - Robot vs Laparoscopic surgery

Study or sub-category	Robotic surgery n/N	Laparoscopic surgery n/N	Weight %	RR (random) 95% CI
Benway	1/129	2/118	29.05	0.46 [0.04, 4.98]
Jeong	1/31	1/23	22.40	0.74 [0.05, 11.25]
Kural	0/11	2/20	19.00	0.35 [0.02, 6.70]
Wang	2/40	1/62	29.55	3.10 [0.29, 33.07]
Total (95% CI)	211	223	100.00	0.85 [0.24, 3.09]

Total events: 4 (Robotic surgery), 6 (Laparoscopic surgery)
Test for heterogeneity: Chi² = 1.76, df = 3 (P = 0.62), I² = 0%
Test for overall effect: Z = 0.24 (P = 0.81)

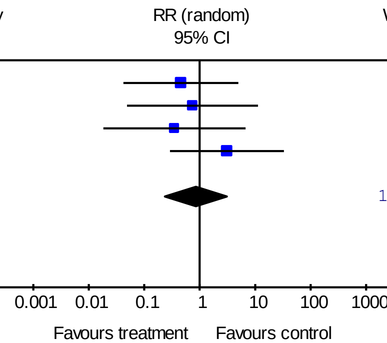
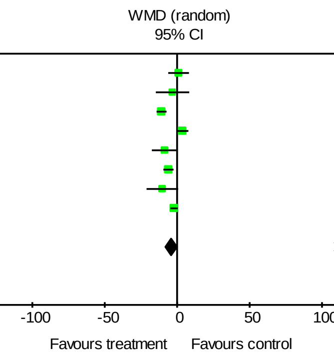


Figure 38, warm ischemic time

Study or sub-category	N	Robotic surgery Mean (SD)	N	Laparoscopic surgery Mean (SD)	Weight %	WMD (random) 95% CI
Aron	12	23.00(6.60)	12	22.00(10.80)	11.47	1.00 [-6.16, 8.16]
Deane	11	32.10(9.30)	11	35.30(17.20)	7.21	-3.20 [-14.76, 8.36]
Benway	129	25.90(7.50)	118	36.70(17.90)	15.97	-10.80 [-14.28, -7.32]
Jeong	31	20.90(6.10)	23	17.20(8.40)	15.31	3.70 [-0.35, 7.75]
Kural	11	27.30(7.90)	20	35.80(17.50)	9.48	-8.50 [-17.48, 0.48]
Wang	40	19.00(5.50)	62	25.00(12.20)	15.97	-6.00 [-9.48, -2.52]
DeLong	13	29.70(8.60)	15	39.90(19.60)	7.67	-10.20 [-21.17, 0.77]
Haber	75	18.20(5.30)	75	20.30(9.90)	16.92	-2.10 [-4.64, 0.44]
Total (95% CI)	322		336		100.00	-4.18 [-8.17, -0.18]

Test for heterogeneity: Chi² = 36.05, df = 7 (P < 0.00001), I² = 80.6%
Test for overall effect: Z = 2.05 (P = 0.04)



CI = confidence interval; LPN = laparoscopic partial nephrectomy; n/N = number of events/sample population; RAPN = robot-assisted partial nephrectomy; RR = risk ratio; SD = standard deviation; WMD = weighted mean difference.

Subgroup and sensitivity analyses based on study design (prospective compared with retrospective), study quality (high or good, compared with remaining scores), and removal of outliers were explored using forest plots to identify systematic variations of the meta-analyses comparing RAPN with LPN. Appendix 11 presents the findings of analyses based on study design (Table A16), study quality (Table A17), and removal of outliers (Table A18). Stratification by study design did not appear to reveal any patterns in the data. No subgroup analysis was conducted based on study quality, because all studies were scored to be of moderate to low quality. For many outcomes, there were no obvious outliers. For blood loss, the removal of two outliers (Aron[106] and Haber[110]) yielded a statistically significant pooled estimate (WMD −31.49, 95% CI −49.58 to −13.41; $P_{heter} = 0.40$). There was insufficient information on surgeons' experience to perform a sensitivity analysis exploring the impact of the learning curve on clinical outcomes.

4.2.3.3.2 Robot-assisted radical nephrectomy compared with laparoscopic radical nephrectomy and open radical nephrectomy

Two studies compared robot-assisted radical nephrectomy (RARN) with laparoscopic radical nephrectomy (LRN).[111,115] The operative time was statistically significantly longer with RARN, and differences in length of stay, blood loss, and complication rates were found to be inconclusive when comparing the two procedures. Nazemi et al.[115] also compared RARN with open radical nephrectomy (ORN). Limited evidence showed that RARN required a longer operative time and led to a shorter length of stay. Data comparing RARN with LRN and ORN are shown in Table 13. There was insufficient information on surgeons' experience to perform a sensitivity analysis exploring the impact of the learning curve on clinical outcomes.

Table 13: Findings — Radical Nephrectomy

Trial	Comparator	Operative Time (minutes)	LOS (days)	Incidence of Transfusion	Blood Loss (mL)	Complication Rate
Hemal*[111]	RARN	221	3.5	3/15 (20%)	210	3/15 (20%)
	LRN	175 (mean difference 45.7; 95% CI 21.8 to 69.6)	3.4 (mean difference 0.1; 95% CI −0.02 to 0.22)	2/15 (13%) (proportion difference 0.02; 95% CI −0.8 to 0.3)	195 (mean difference 15.3; 95% CI −4.7 to 35.3)	2/15 (13%) (proportion difference 0.07; 95% CI −0.91 to 0.33)
Nazemi†[115]	RARN	345	3	1/6 (16%)	125	NR
	LRN	237 (P = 0.02)	4 (P = 0.03)	2/12 (17%) (NS)	125 (NS)	NR
Nazemi[115]	RARN	345	3	1/6 (16%)	125	1/6 (16%)
	ORN	202 (P = 0.02)	5 (P = 0.03)	1/6 (16%) (NS)	500 (P =0.01)	3/18 (16%)

LOS = length of stay; LRN = laparoscopic radical nephrectomy; NR = not reported; NS = difference is not statistically significant; ORN = open radical nephrectomy; RARN = robot-assisted radical nephrectomy.
Confidence intervals have been provided where available.
* Data reported in mean.
† Data reported in median.

4.2.3.4 Cardiac Surgery

Data comparing robot-assisted cardiac surgery with non–robot-assisted cardiac procedures are scarce. The comparators differ among studies, so we did not perform a meta-analysis. Six trials compared robot-assisted cardiac surgeries, including mitral valve repair,[118,121,122] CABG,[123] and septal defect repair,[116,117] with non–robot-assisted procedures. Robot-assisted cardiac procedures generally required longer operative times, but provided shorter length of hospital stay compared with non–robot-assisted procedures. Findings on transfusion rates and complication rates are inconsistent between robot-assisted and non–robot-assisted procedures. The study results for these outcomes are shown in Table 14.

Table 14: Cardiac Surgery

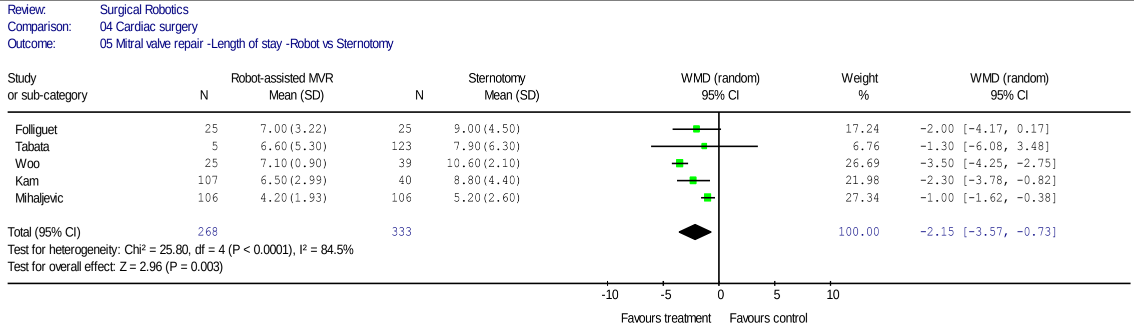
Trial	Comparator	Operative Time (minutes)	LOS (days)	Transfusion Rate	Complication Rate
Ak[116]	RA ASDR	262.6 ± 60.6	7.9 ± 1.9	1/24	3/24
	PLS	147.3 ± 21.3 (P = 0.000)	8.2 ± 2.2 (NS)	0/16	3/16
Morgan[117]	RA ASDR	155 ± 61.5	5.6 ± 2.6	NR	NR
	Mini thoracotomy	66.7 ± 38.2 (P < 0.001)	6.6 ± 3.7(NS)	NR	NR
Folliguet[118]	RA MVR	241 ±53.3	7 ± 3.22	2/25	8/25
	Sternotomy	188 ± 24.3 (P = 0.002)	9 ± 4.5 (NS)	4/25 (NS)	5/25
Tabata[121]	RA MVR	213 ± 52	6.6 ± 5.3	NR	NR
	Sternotomy	125 ± 39	7.9 ± 6.3 (P not reported)	NR	NR
Woo[122]	RA MVR	239 ± 12	7.10 ± 0.9	NR	NR
	Sternotomy	162 ± 10 (P < 0.001)	10.6 ± 2.1 (P = 0.039)	NR	NR
Mihaljevic[120]	RA MVR	387	4.2 ± 1.93	NR	54/106
	Sternotomy	278 (P < 0.0001)	5.2 ± 2.6 (P < 0.001)	NR	71/106
Kam[119]	RA MVR	238.6	6.5 ± 2.99	NR	NR
	Sternotomy	201.8 (mean relative difference 1.18; 95% CI 1.11, 1.27; P < 0.001)	8.8 ± 4.4 (mean relative difference 0.74; 95% CI 0.68, 0.80; P < 0.001)	NR	NR
Poston[123]	RA CABG	348	3.77 ± 1.51	NR	24/100
	CABG	246 (P < 0.001)	6.38 ± 2.23 (P < 0.001)	NR	57/100 (NS)

ASDR = atrial septal defect repair; CABG = coronary artery bypass grafting; LOS = length of stay; MVR = mitral valve repair; NR = not reported; NS = difference is not statistically significant; PLS = partial lower sternotomy; RA = robot-assisted. Standard deviations and 95% confidence intervals provided where available.

Because the outcome on length of stay was considered in the economic analysis, data on length of hospital stay were pooled (Figure 39). The length of hospital stay of patients undergoing robot-assisted surgery was found to be shorter, on average, by more than two days compared with patients undergoing conventional surgery. Statistical heterogeneity was identified; however, all five studies were associated with point estimates that favoured robotic surgery.

Figure 39: Cardiac Surgery

Length of stay



CI = confidence interval; MVR = mitral valve repair; N = sample population; SD = standard deviation; WMD = weighted mean difference.

4.3.3 Summary of Findings from Clinical Review

In a comparison of robot-assisted surgery with open and laparoscopic approaches that was conducted for multiple indications, a series of clinical outcomes were considered. Robot-assisted surgery was shown to be associated with shorter lengths of hospital stay than open and laparoscopic prostatectomy, open and laparoscopic hysterectomy, and laparoscopic partial nephrectomy. Reduced blood loss and transfusion rates were also associated with robot-assisted surgery compared with open and laparoscopic prostatectomy and open hysterectomy. Robotic assistance reduced positive margin rates compared with open prostatectomy in pT2 patients, and reduced postoperative complication rates compared with open and laparoscopic hysterectomy. Robot-assisted surgery was associated with increased operative time compared with open prostatectomy and open hysterectomy, and with reduced operative time compared with laparoscopic prostatectomy. All these differences were statistically significant at an alpha level of 5%. Findings on robot-assisted cardiac surgery were scarce but tended to favour robot-assisted surgery in terms of length of hospital stay.

Several limitations of the evidence are mentioned here, to allow for a better understanding of the clinical interpretations. Several of the meta-analyses that were done were found to be associated with statistically significant heterogeneity based on I^2 measures and chi^2 tests. Inspecting study estimates of effectiveness in relation to study quality and study design did not show any systematic patterns. Efforts were made to review additional relevant information from all included studies that represented potential sources of heterogeneity; however, the benefits of these efforts were small because of limited availability and approaches to reporting of key information in the studies. Because of this, the chosen clinically important potential causes of heterogeneity generally did not explain the heterogeneity that was observed. This may also be a consequence of the observational design of the included studies. Development of answers to the research questions based on pooled data from observational studies and with the unexplained heterogeneity associated with summary estimates is needed while considering these limitations. The presence of sometimes-contradictory studies also complicates this task. Although statistically significant benefits were observed for several outcomes across indications and are based on large sample sizes, there may be uncertainty about the clinical relevance of the sizes of observed differences.

Methodological limitations of the included studies and the presence of inconsistency of findings between studies are additional concerns that warrant a cautious interpretation of findings. No randomized studies were found on any indication, and many studies used a retrospective design, which did not include considerations such as matching and which included multiple surgeons. The evidence may be considered to be of lower quality, given these limitations.

Comparisons between the methods of surgery in terms of survival rates and time to return to work were inconclusive, because of the scarcity of the evidence. The findings on main outcomes for all four indications based on analyses done in this review are shown in Table 15.

Table 15: Findings from Comparisons of Robot-Assisted Surgery with Open and Laparoscopic Surgery

Indication	Operative Time	LOS	Positive Margin Rate	Incidence of Transfusion	Complications
Prostatectomy	38 minutes longer than open surgery 23 minutes faster than laparoscopic surgery	1.5 fewer days than open surgery 0.8 fewer days than laparoscopic surgery	39% reduction in risk of PMR for pT2 patients compared with open surgery (inconclusive for pT3 patients) Inconclusive compared with laparoscopic surgery	80% reduction in risk compared with open surgery 46% reduction in risk compared with laparoscopic surgery	27% reduction in risk compared with open surgery Inconclusive compared with laparoscopic surgery
Hysterectomy	64 minutes faster than open surgery Inconclusive compared with laparoscopic surgery	2.6 fewer days than open surgery 0.22 fewer days than laparoscopic surgery	NA	75% reduction in risk compared with open surgery Inconclusive compared with laparoscopic surgery	62% reduction in risk compared with open surgery 46% reduction in risk compared with laparoscopic surgery
Radical nephrectomy **Partial nephrectomy**	143 minutes faster than open surgery (data from 1 trial) Inconclusive compared with laparoscopic surgery	2 fewer days less than open surgery (data from 1 trial) 0.25 fewer days than laparoscopic surgery	NA	Same rate compared with open surgery (data from 1 trial) Inconclusive compared with laparoscopic surgery	Same risk compared with open surgery (data from 1 trial) Inconclusive compared with laparoscopic surgery

Table 15: Findings from Comparisons of Robot-Assisted Surgery with Open and Laparoscopic Surgery					
Indication	**Operative Time**	**LOS**	**Positive Margin Rate**	**Incidence of Transfusion**	**Complications**
Cardiac surgery	RACS seems to have longer operative time than non-RACS (non-pooled data)	RACS 2 fewer days than non-RACS	NA	NA	NA

LOS = length of stay; NA = not available; PMR = positive margin rate; RACS = robot-assisted cardiac surgery

5 ECONOMIC ANALYSIS

5.1 Review of Economic Studies: Methods

A review of the economic literature was conducted to assess the reported cost-effectiveness of robot-assisted surgery compared with open or laparoscopic approaches, in prostatectomy, hysterectomy, nephrectomy, and cardiac surgeries.

5.1.1 Literature searches

Peer-reviewed literature searches were conducted for the economic evaluation. An information specialist developed the economic search strategy with input from the project team.

In addition to the bibliographic databases and grey literature sources that were searched for the clinical review (Appendix 2), parallel searches were run in the Health Economic Evaluations Database (HEED). The search strategy comprised controlled vocabulary, such as the National Library of Medicine's MeSH (Medical Subject Headings), and keywords. The main search concepts focused on surgical robotics for prostatectomy, hysterectomy, nephrectomy, and cardiac surgeries (including but not restricted to coronary artery bypass graft and mitral valve repair surgery). A methodological filter was applied to limit retrieval to economic studies. See Appendix 2 for the detailed search strategies.

The economic search did not have a date limit and was limited to the English and French languages. Ovid AutoAlerts were set up to send monthly updates with new literature. Updates were performed on HEED, PubMed, and The Cochrane Library databases. Targeted supplemental searches were also performed.

5.1.2 Selection criteria

Studies with the following characteristics were considered for inclusion in the economic review:

- Study design: cost-effectiveness analysis, cost-utility analysis, cost-minimization analysis, cost-benefit analysis, and cost-consequences analysis
- Population: individuals undergoing robot-assisted surgery for prostatectomy, hysterectomy, nephrectomy, and cardiac surgeries (including but not restricted to CABG procedure and mitral valve repair surgery)

- Intervention: robot-assisted surgery with da Vinci System
- Comparator: open and laparoscopic procedures for selected indications
- Outcomes: quality-adjusted life-years, disability-adjusted life-years, life-years saved, operative time, reduction of blood loss, reduction of pain, positive margin rate, time to mobilization, functional outcomes, complication rates, length of hospital stay, time to return to work or resuming normal activities.

5.1.3 Selection method

Two reviewers (ET, CH) independently screened the titles and abstracts of all citations that were retrieved during the literature search and ordered the full text of articles that met the selection criteria. The reviewers then independently reviewed the full text of selected articles, applied the selection criteria to them, and compared the independently chosen included and excluded studies. Disagreements were resolved through discussion until consensus was reached. Duplicate publications of the same study were excluded.

5.1.4 Data extraction strategy

One reviewer (ET) extracted data to be used in the economic review using a data extraction form (Appendix 12). Evidence tables were then constructed, using the data from the completed extraction forms. A second reviewer (SP) verified data entered in the evidence tables.

5.1.5 Strategy for validity assessment

The reporting quality of economic evaluations was assessed using the Drummond and Jefferson checklist.[127] The studies are evaluated based on their reporting on 35 criteria on study design, data collection, and the analysis and interpretation of results. Study characteristics that may affect the quality or validity of evidence were addressed in the qualitative analysis of the retrieved economic studies.

The external validity of each study was evaluated through a series of questions that are based on CADTH Economic Guidelines.[128] The questions ask whether the study research question reflects the issue; the clinical data that are used in the analysis reflect what might be seen in routine clinical practice in Canada; the resource use patterns and relative unit costs are generalizable to Canada; and the uncertainty is adequately reflected in the analysis. This tool has been used in previous CADTH assessments.

One reviewer (ET) assessed the studies, and a second reviewer (CH, KC, SB) reviewed and confirmed the results of the assessment.

5.1.6 Data analysis methods

In a narrative description of the studies, the characteristics and main findings of the studies were described, the strength of evidence was assessed, and the study limitations were noted.

5.2 Review of Economic Studies: Results

5.2.1 Quantity of research available

A total of 486 citations were identified: 445 citations from the economic literature search, 30 from the grey literature, 10 through handsearching of selected references, and one through the clinical literature search. Of these 486 citations, 441 were excluded in the initial selection. Most of the citations were excluded because they did not appear to be economic assessments of robotic surgery. After full text review of the 45 remaining articles, a further 15 were excluded. Of these 15, six were duplicate studies, four were not economic evaluations, two were not comparative economic evaluations, one focused on an indication that had not been selected, one had data on indications that were not specific enough, and one did not focus on the da Vinci robot. A list of the excluded studies is shown in Appendix 13.

Of the 30 economic assessments selected for this review, 15[129-143] were on prostatectomy, four[119,123,144,145] were on cardiac surgery, two[115,146] were on radical nephrectomy, eight[86,96,102,147-151] were on hysterectomy, and one study[58] considered multiple indications (including prostatectomy, nephrectomy, and carotid bypass). Five of the studies[132,137,140,142,144] were reported in abstract form, 24[58,86,96,102,115,119,123,129,131,133-136,138,139,141,143,145-151] were reported as full articles, and one[130] was a technology assessment. Twenty-three studies originated in the United States,[58,96,102,115,123,129-131,133,135-139,141-148,150] two were from Australia,[119,134] two were from the United Kingdom,[132,149] one was from Switzerland,[151] one was from Denmark,[140] and one study[86] was conducted in Canada.

5.2.2 Study characteristics

a) Study quality

The evaluation of the six abstracts[132,137,140,142,144,150] found the quality of their reporting of study design, data collection, and analysis and interpretation of results to be poor overall; however, this is expected, given the limited information that is generally available in abstract form. Of the remaining 24 reports, all had limitations in the reporting of study design and of analysis and interpretation of results, with the greatest limitations seen in the reporting of data collection. Common omissions among this category of criteria included the discussion of the relevance of productivity changes, the reporting of resource quantities separate from unit costs, the recording of currency and price, details of currency and price adjustments, and justification and details on the model chosen. Ten studies[86,123,129,130,136,138,139,145,147,148] reported partially or fully on at least 75% of the Drummond and Jefferson checklist criteria.[127] The results of this evaluation are shown in Appendix 14.

b) External validity

The research questions of the reviewed studies reflected the issue in most cases, with four studies[131,132,136,139] partially reflecting the research questions. Because patient populations, practice patterns, and resource prices may differ in other countries, the clinical data used in the analyses were considered to partially reflect what might be achieved in routine clinical practice in Canada in 20 studies,[96,102,115,119,123,129,130,133-135,139-141,144,146-151] and resource use patterns and relative unit cost levels were considered to be partially generalizable to Canada in all studies except Halliday's Canadian study.[86] The clinical data from Halliday et al.'s study[86] were from a

Canadian setting, and clinical outcomes data were not reported in nine studies.[58,131,132,136-138,142,143,145] Six studies[86,131,136,138,140,147] were considered to at least partially reflect uncertainty in their analyses. The results of the external validity assessment are shown in Appendix 15.

c) Study designs

Of the studies, 11[58,129,132,135-138,142,143,145,147] were costing analyses, 15[86,96,102,115,119,123,133,139,141,144,146,148-151] were cost-consequences analyses, one[131] was a cost-benefit analysis, two[130,134] were cost-utility analyses, and one[140] conducted cost-effectiveness and cost-utility analyses.

d) Time horizon

Ollendorf et al.'s cost-utility analysis[130] had a lifetime time horizon, and O'Malley and Jordan's cost-utility analysis[134] and Hohwü et al.'s cost-utility analysis [140] had time horizons of one year. Five studies[102,115,123,133,144] considered only the length of the hospital stay for the costs, and periods of between one month and 31 months for patient outcomes. One study[147] evaluated hospitalization costs outcomes, and lost productivity and caregiver costs up to 52 days post-discharge from hospital. Pasic et al.[148] evaluated patient outcomes and costs up to 30 days post-discharge. Halliday et al.[86] assessed patient outcomes and costs for the length of hospital stay with an allowance for one readmission. The time horizon for the remaining 19 studies[58,96,119,129,131,132,135-139,141-143,145,146,149-151] was the length of the hospital stay.

e) Study perspective

The study perspective determines which costs are included in an economic evaluation. The two cost-utility analyses,[130,134] one cost-consequences analysis,[102] and one costing study[147] were conducted from a societal perspective. The costing study was also conducted from a hospital perspective. Two studies[86,140] were conducted from the perspective of a publicly funded health care system. Twenty studies[58,96,119,129,131,132,135-139,141,142,144-146,148-151] were conducted from the perspective of a hospital. One study[143] was conducted from the perspective of the surgeon's hospital. Three studies[115,123,133] considered the hospital perspective only for costs and patient outcomes post-discharge.

f) Study populations

Prostatectomy

Among the 16 studies on prostatectomy, six[129,130,133,139-141] described the baseline characteristics of the study populations. Two other prostatectomy studies[135,137] did not provide details on group baseline characteristics, but noted that they were comparable between groups.

Bolenz et al.[129] included 643 patients who underwent radical prostatectomy (262 robotic, 220 laparoscopic, 161 open retropubic). The patient and disease characteristics were comparable among the three groups. The median age of the three groups ranged from 59 years to 61 years, the median BMI ranged from 27 kg/m^2 to 28 kg/m^2, the median preoperative prostate-specific antigen (PSA) ranged from 5.0 ng/mL to 5.3 ng/mL, and the median prostate volume ranged from 45 cm^2 to 46 cm^2. The proportion of patients with a Gleason score of between 8 and 10 was 7.5% (Gleason scores have a range of 2 to 10, with higher scores indicating poorer prognosis). In a later analysis of this group of patients, Bolenz et al.[139] assessed the impact of BMI (BMI less than 30 kg/m^2 compared with BMI greater than 30 kg/m^2) on the costs associated with these three surgical approaches to prostatectomy. There were no statistically significant differences in patient characteristics in terms of the BMI category.

Hohwü et al.[140] described only the age range of the patient populations (50 years to 69 years for open and robotic).

The clinical data for the cost-utility analysis that was modelled by Ollendorf et al.[130] were obtained from systematic reviews and from other sources in the literature. The base case patient for this assessment was a 65-year-old male with clinically localized prostate cancer and a low risk of recurrence. The authors defined patients with a low risk of recurrence as having stage T1 to T2a lesions, Gleason scores of between 2 and 6, and PSA levels of less than 10 ng/mL.

Joseph et al.[141] included data from 233 radical prostatectomy patients (106 robotic, 57 laparoscopic, 70 open). The mean ages in the robotic, laparoscopic, and open groups were 60.0 years, 57.6 years, and 53.6 years, respectively. The mean preoperative PSA in these three groups was 6.6 ng/mL, 8.4 ng/mL, and 7.2 ng/mL, respectively. The mean Gleason score was 6 in all three groups.

Mouraviev et al.'s[133] study was based on 452 consecutive patients who underwent surgery for clinically localized prostate cancer (197 radical retropubic [RRP], 60 radical perineal [RPP], 137 robotic, and 58 cryosurgical ablation [CAP]). Patients were excluded if they had undergone neoadjuvant chemotherapy or hormonal therapy, transurethral resection or laser prostatectomy, any salvage prostatectomy, or multiple surgical procedures during the same operation. The mean age of patients undergoing CAP was statistically significantly higher than that of the other three groups (67 years ± 7 compared with 60 years ± 6 [RRP], 60 years ± 7 [RPP], 59 years ± 7 [robotic]; $P < 0.005$). The mean American Society of Anesthesiologists scores, which were comparable in the four groups, averaged 2.2 (range 1 to 5, with lower scores representing better physical status) for all patients.

Cardiac Surgery

Four[119,123,144,145] of the five studies in robotic cardiac surgery described the patient populations.

Bachinsky et al.[144] compared 18 patients who underwent robot-assisted hybrid coronary artery revascularization (HCR) with 26 patients who underwent off-pump coronary artery bypass (OPCAB). The authors provided only the average baseline Syntax Scores (a measure of coronary artery disease severity, where scores greater than 33 are considered high), which were 34.5 ± 8.8 and 35.5 ± 8.5 for HCR and OPCAB, respectively.

Kam et al.[119] studied 40 patients undergoing conventional MVR and 107 patients who underwent robot-assisted MVR. There were no statistically significant baseline differences in the conventional and robotic groups in age (61.6 years ± 11.16 compared with 57.6 years ± 13.67, respectively), gender distribution (82.5% males compared with 71.0% males, respectively), mitral valve pathology (posterior 84.8% compared with 72.3%, respectively; anterior 2.6% compared with 6.9 %, respectively; both 12.8% compared with 18.8%, respectively), hypertension (38.5% compared with 30.2%, respectively), diabetes mellitus (2.6% compared with 0.9%, respectively), prior myocardial infarction (0% compared with 0.9%, respectively), prior cerebrovascular accident (5.1% compared with 3.8%, respectively), peripheral vascular disease (0% for both), or prior coronary artery bypass grafting (CABG; 0% for both). There was a statistically significant difference in preoperative mitral regurgitation severity between the conventional and robotic groups (moderate-severe 17.5% compared with 5.8%, respectively; severe 82.5% compared with 94.2%, respectively).

Poston et al.[123] included 100 patients who underwent minimally invasive coronary artery bypass grafting (mini-CABG) and 100 patients who underwent traditional OPCAB. Patients were included in the mini-CABG group if they had multivessel coronary artery disease involving anterior and lateral coronary branches that were deemed suitable targets for grafting via a mini-thoracotomy. Patients who were hemodynamically unstable; who could not be provided with complete revascularization; who had severe pulmonary and vascular disease, decompensated heart failure, or arrhythmia; or who were allergic to radiographic contrast were excluded from the mini-CABG group. OPCAB patients were matched to mini-CABG patients on risk factors that influence the propensity to perform mini-CABG. The mean ages of patients in the mini-CABG and OPCAB groups were 61.8 ± 9.4 years and 66.2 ± 10.1 years, respectively. In the mini-CABG group, 72% of patients were male, and in the OPCAB group, 63.3% of patients were male. The mini-CABG and OPCAB groups were comparable in BMI (29.9 ± 9.7 kg/m^2 and 28.4 ± 6.7 kg/m^2, respectively), risk factors (smoking, family history of coronary artery disease, diabetes, dyslipidemia, and hypertension), comorbidities, history of cardiovascular disease, and preoperative medications. Approximately 19.5% of all patients were categorized using All Patient Refined–Diagnosis-Related Group (APR-DRG, an illness severity classification) categories as being in the extreme class IV mortality risk, with an average EuroSCORE of 15.7 (the EuroSCORE predicts the risk of operative mortality in patients undergoing cardiac surgery). The remaining 80.5% patients were APR-DRG Classes I to III, with an average EuroSCORE of 4.9. There were no between-group differences in the risk of mortality.

Morgan et al.[145] studied 20 patients who underwent atrial septal defect (ASD) closure (10 robotic, 10 sternotomy) and 20 patients who underwent MVR (10 robotic, 10 sternotomy). The mean ages of patients undergoing ASD were 42.0 ± 13.3 years in the sternotomy group and 46.6 ± 10.5 years in the robotic surgery group. In both groups, 40% of patients were male. None of the ASD patients had a prior myocardial infarct (MI), CABG, diabetes, or peripheral vascular disease. In both groups, 40% of patients had hypertension. The mean ejection fraction was 56.6 ± 6.5 among sternotomy patients, and 59.2 ± 5.3 among robotic surgery patients. Three sternotomy patients and four robotic surgery patients had a cerebrovascular accident, and one patient in the sternotomy group was a smoker. Among patients undergoing MVR, the mean age was 59.8 ± 17.5 years in the sternotomy group and 52.8 ± 11.2 years in the robotic surgery group. In the sternotomy group, 30% of patients were male, as were 80% of patients in the robotic surgery group. Thirty percent of patients in the sternotomy group and 10% in the robotic surgery group had a prior MI. One patient in the sternotomy group had a prior CABG. The mean ejection fraction was 46.7 ± 15.4 in the sternotomy group, and 57.9 ± 6.4 in the robotic surgery group. Among sternotomy and robotic surgery patients, 60% and 20% had hypertension, 10% and 0% had diabetes, 0% and 10% had peripheral vascular disease, 10% and 0% had a cerebrovascular accident, and 30% and 10% were smokers, respectively.

Nephrectomy

Two[115,146] of the three studies in nephrectomy described the patient populations.

Boger et al.[146] compared 13 patients who were operated on robotically with 46 patients who underwent laparoscopic nephrectomy and 20 patients who underwent hand-assisted laparoscopic nephrectomy. Reported baseline characteristics included gender distribution (52% males to 62% males), BMI (29 kg/m^2 to 30 kg/m^2), and preoperative creatinine (1.0 mg/dL to 1.5 mg/dL). There appeared to be between-group differences in the distribution of diagnosis (renal mass compared with polycystic kidney disease compared with kidney failure); however, this distribution was not evaluated statistically. Renal mass size (in centimetres) in the laparoscopic, hand-assisted laparoscopic, and robotic groups was 5.8, 7.2, and 4.8, respectively.

Nazemi et al.[115] studied 57 consecutive patients undergoing radical nephrectomy in four surgical groups (18 open, six robotic, 21 hand-assisted laparoscopy, 12 laparoscopy). The median age in the four groups ranged from 57 years to 69 years. Between 71% and 83% were male. The median BMI ranged from 27.5 kg/m^2 to 29.2 kg/m^2. Between 67% and 83% had a malignant final pathological diagnosis, between 0% and 17% had a diagnosis of oncocytoma, and between 17% and 22% had a diagnosis of benign tumour. The median specimen size ranged from 3.95 cm to 5.35 cm, and the incidence of renal cell cancer ranged from 67% to 83%. There were no statistically significant differences between groups in TNM cancer stage, with 25 of the 42 renal cell cancer patients being stage T1a or T1b. The groups were comparable in Fuhrman grade, with most patients (between 58% and 87%) being grade 2. The median follow-up in the four groups ranged from four to 15 months (overall range of one to 31 months). Disease recurred in two patients in the open surgical group.

Hysterectomy

Of the eight studies that reported on hysterectomy, seven[86,96,102,148-151] described the patient populations.

Halliday et al.[86] studied 40 patients undergoing hysterectomy (24 open and 16 robotic). The open and robotic groups were comparable in age (47 ± 12 years and 49 ± 10 years, respectively), BMI (25 ± kg/m^2 and 26 ± 6 kg/m^2, respectively), parity (2 ± 1 and 2 ± 2, respectively), gravidity (2 ± 2 and 3 ± 2, respectively), major comorbidities (46% and 44%, respectively), smoking status (42% and 31%, respectively), and American Society of Anesthesiologists Score (2 ± 1 in both groups). There were no statistically significant between-group differences in prior abdominopelvic surgeries, cancer stage, tumour grade, or histological subtype (squamous cell compared with non-squamous cell carcinoma).

Holtz et al.[96] compared 13 robotically performed with 20 laparoscopically performed hysterectomies. The mean age was 63 years in both groups. No statistically significant between-group differences were found in comorbidity (diabetes or hypertension), smoking status, tumour stage, or International Federation of Gynecology and Obstetrics (FIGO) tumour grade. Patients undergoing robotic surgery had a statistically significantly higher BMI than those who had laparoscopic surgery (35.3 ± 10.7 kg/m^2 compared with 27.8 ± 7.1 kg/m^2; $P = 0.04$).

Pasic et al.[148] included 1,661 robotic (1,282 inpatient, 379 outpatient) and 34,527 laparoscopic (25,789 inpatient, 8,738 outpatient) hysterectomy cases. The average age in the four groups of patients ranged from 43.8 to 48.8 years. Sixty-seven per cent of robotically operated patients and 79% of laparoscopically operated patients were non-complex cases, and almost all inpatient cases in the robotic and laparoscopic groups (98% and 99%, respectively) were APR-DRG levels 1 and 2.

Raju et al.[149] reported the average age of the 16 patients in the robotic hysterectomy group as 53 years (range 32 years to 63 years).

Wright et al.[150] reported the age range of all patients, regardless of surgical group, as 18 years to 91 years.

Sarlos et al.[151] compared 40 robotic hysterectomies with 40 laparoscopically performed hysterectomies in a case-control study. The mean age was 45.3 years and the average BMI was 26 kg/m^2. The mean intraoperative uterine weight in the robotic and laparoscopic groups was 217 g and 195 g, respectively.

Bell et al.[102] studied 110 patients (40 laparotomy, 30 laparoscopy, 40 robotic) undergoing hysterectomy and lymphadenectomy for endometrial cancer staging. The mean age of patients undergoing robotic surgery (63.0 ± 10.1 years) was statistically significantly different from that of patients undergoing laparotomy (72.3 ± 12.5 years; P = 0.0005), and from that of patients undergoing laparoscopic surgery (68.4 ± 11.9 years; P = 0.03). There were no statistically significant differences between groups in terms of BMI (laparotomy 31.8 ± 7.7 kg/m^2, laparoscopy 31.9 ± 9.8 kg/m^2, robotic 33.0 ± 8.5 kg/m^2) and uterine weight (laparotomy 155.6 ± 134.8 g, laparoscopy 138.5 ± 75.5 g, robotic 135.9 ± 72.8 g; differences not statistically significant).

g) Intervention and comparator

Among the studies on prostatectomy, six studies[129,132,138,139,141,143] compared robotic prostatectomy with laparoscopic surgery and open surgery, one study[131] compared robotic prostatectomy with laparoscopic surgery, one study[133] compared robotic surgery with open surgery and cryosurgical ablation, and the remaining eight studies[58,130,134-137,140,142] compared robotic surgery with open surgery.

The five cardiac surgery studies[58,119,123,144,145] compared robotic surgery with conventional (thoracotomy or sternotomy) approaches.

One nephrectomy study[146] compared robotic surgery with laparoscopic surgery (with and without hand assistance), a second study[115] compared robotic surgery with open surgery and with laparoscopic surgery (with and without hand assistance), and the comparator in the third study[58] was open surgery.

Of the eight hysterectomy studies, four[102,147,149,150] focused on robot-assisted surgery compared with laparoscopy and with laparotomy, three[96,148,151] focused on robot-assisted surgery compared with laparoscopy, and one study[86] focused on robot-assisted surgery compared with laparotomy.

h) Economic outcomes

Of the 30 studies that were reviewed, 28 reported mean or median total costs of care. Steinberg et al.[131] reported results in terms of net profit, and Guru et al.[137] reported results in terms of the percent difference in robotic prostatectomy costs compared with those of open prostatectomy. Three cost-utility studies[130,134,140] estimated quality-adjusted life-years. Fourteen studies[86,96,102,115,123,135,136,138,146-151] reported operating room time, and 25 studies[58,86,96,102,115,119,123,129,133-139,141,142,144-151] reported the length of hospital stay. Four studies[102,123,147,149] considered time to return to work and normal activities, and three studies[102,134,147] reported lost wages and household productivity. One study[130] considered patient time costs in the calculations, but did not report them separately.

i) Economic costs

There was variability between studies regarding the costs that were included in the analyses. Among the costs that were included in the studies were the capital equipment (robot) costs, the cost of the robot annual maintenance contract, the cost of the robotic surgery disposables, operating room costs, the cost of supplies, the cost of anesthesia, the cost of medication, the cost of room and board (intensive care unit [ICU] and ward), laboratory costs, procedure costs, outpatient costs, nursing fees, other medical staff fees, transfusion costs, and productivity costs. Eleven studies[96,119,129,130,132,133,139,143,146,148,151] did not include the cost of the robot in the analyses, and the inclusion of the cost of the robot was unclear in seven studies.[58,115,119,135,140,142,150] Six studies included the cost of the robot,[102,134,136,141,147,149] and six studies[86,123,131,137,138,145] conducted analyses with and without the cost of the robot included in the estimates. Most studies that included the cost of the robot in the estimates also included the cost of the robot annual maintenance contract and of disposables. One study[132] that did not include the cost of the robot in the analysis did consider the cost of maintenance and disposables. Five analyses[102,123,131,137,145] amortized the cost of the robot over five years, five[86,134,136,138,147] amortized this cost over seven years, and two[141,149] did not describe an amortization period. The treatment of robotic surgery costs in each study is summarized in Appendix 16. Among the other costs that were considered in these studies, those most commonly included were the cost of room and board, the cost of operating room time, the cost of medications, and laboratory costs.

j) Funding sources

Ollendorf et al.'s study[130] was conducted through the Institute for Clinical and Economic Review, which receives its funding from insurance organizations, pharmaceutical companies, and foundations. Bolenz et al.,[129] Guru et al.,[137] and Barnett et al.[147] declared that they had no source of funding. Poston et al.[123] declared that the lead author was supported by grants from the National Institutes of Health and the American Heart Association. Sarlos et al.[151] received government and institutional funding. Kam et al.'s study[119] was funded by a research fellowship and an insurance company, Halliday et al.[86] and Raju et al.[149] were funded by research awards and foundation grants, and Pasic et al.'s study[148] was industry funded. The remaining 20 reports made no declarations about the source of funding. The study characteristics are summarized in Tables A22 and A23 in Appendix 17.

5.2.3 Study results

a) Base case results

Prostatectomy

Bolenz et al.[129] reported that the proportion of nerve-sparing procedures was statistically significantly different between robotic (85%), laparoscopic (96%), and open (90%) methods ($P < 0.001$). Differences were also seen in lymphadenectomy rates (robotic 11%, laparoscopic 22%, open 100%; $P < 0.001$), blood transfusion rates (robotic 4.6%, laparoscopic 1.8%, open 21.0%; $P = 0.001$), median operating room time (robotic 235 minutes, laparoscopic 225 minutes, open 198 minutes; $P < 0.001$), and median length of hospital stay (robotic 1 day, laparoscopic 2 days, open 2 days; $P < 0.0001$). The authors reported statistically significantly different median direct costs in robotic ($6,752), laparoscopic ($5,687), and open ($4,437) surgical methods ($P < 0.0001$). This difference was largely attributed to the relative median costs of the operating room (robotic $2,798, laparoscopic $2,453, open $1,611; $P < 0.001$), and costs of surgical supplies (robotic $2,015, laparoscopic $725, open $185; $P < 0.001$). Bolenz et al.'s 2010 analysis[139] of the same patient groups by BMI category (less than 30 kg/m^2 compared with 30 kg/m^2 or more) found that patients with a BMI of 30 kg/m^2 or more had statistically significantly higher median total costs in the laparoscopic ($5,703 compared with $5,347; $P = 0.002$) and open ($4,885 compared with $4,377; $P = 0.004$) surgery groups, but not in the robotic surgery group ($6,761 compared with $6,745; P is not significant).

In their abstract, Hohwü et al.[140] reported a between-group procedure success difference of 7% in favour of robotic surgery, and an incremental cost-effectiveness ratio for robotic compared with open prostatectomy of €64,343 per treatment success, where a treatment success was defined as postoperative PSA less than 0.2 ng/mL, preserved urinary continence, and erectile function. The authors also conducted a cost-utility analysis, but they found no difference in quality-adjusted life-year (QALY) gains with robotic surgery at one year, and these results were not reported.

Laungani and Shah[142] described reductions in lengths of hospital stay as their institution switched from open prostatectomy to a robotic program (2.72 days to 1.08 days). The initial average costs per case were higher with the robotics group ($25,593 compared with $16,495), but after two years, the average cost per patient undergoing robotic prostatectomy declined to a level below that of open surgery ($14,481).

Lotan et al.'s[143] US study reported higher average total hospital costs among patients undergoing robotic prostatectomy ($10,269) than open surgery ($6,473) and laparoscopic ($8,557) surgery. After accounting for payments, they found that of the three surgical approaches, robotic surgery was the least profitable to the hospital, but the most profitable to the surgeon.

Ollendorf et al.[130] estimated the total discounted costs of robotic prostatectomy to be lower than those of open prostatectomy ($26,608 compared with $28,348). Robotic surgery involved higher surgeon payments and anesthesia reimbursements, and lower costs for subsequent visits and complications. Robotic surgery was more effective than open surgery, resulting in more QALYs (7.98 discounted QALYs compared with 7.82 discounted QALYs).

Joseph et al.[141] estimated higher total operating room costs with robotic prostatectomy ($5,410) than laparoscopic surgery ($3,876) and open surgery ($1,870), with most of the costs attributed to the cost of supplies.

Steinberg et al.[131] did not assess clinical outcomes; however, they reported that the purchase of a robot reduced hospital income by at least $415,000 per year, and that an institution must increase its caseload when switching from laparoscopic to robotic surgery, to maintain an equivalent profit. The authors assumed a profit of $5,409 per case. To cover the cost of a purchased robot, 78 cases per year were needed, and 20 cases per year were needed if the robot was donated.

Mayer et al.[132] compared the costs (nursing, medical staff, service contract, consumables, and hospital stay) for robotic surgery and laparoscopic surgery with the national tariff for open surgery. All three surgeries were reimbursed at the national tariff rate for open surgery in the United Kingdom. The clinical outcomes were not assessed. The total costs for robotic surgery and laparoscopic surgery were £6,704.84 and £4,755.75, respectively, and the national tariff rate for open prostatectomy was £3,701.00.

In their comparison of costs and outcomes, Mouraviev et al.[133] found that the mean length of hospital stay was statistically significantly lower among patients undergoing CAP (0.16 ± 0.14 days) compared with the radical retropubic prostatectomy (RRP; 2.79 ± 1.46 days), radical perineal prostatectomy (RPP; 2.87 ± 1.43 days), and robotic prostatectomy (2.15 ± 1.48 days) groups ($P < 0.005$). Comparing RRP, RPP, and robotic only, a smaller proportion of robotic surgery patients had seminal vesicle invasion (2.2% compared with 7.6% [RRP] and 9.0% [RPP]; $P = 0.0115$), and a Gleason score of more than 7 (3.6% compared with 13.7% [RRP] and 11.9% [RRP]; $P < 0.0001$). The proportion of patients with positive margins in the RRP, RPP, and robotic groups was 20.3%, 25.4%, and 30.2%, respectively. The mean total hospital costs were lower in the robotic group ($10,047) and in CAP ($9,195), compared with the RRP and RPP groups ($10,704 and $10,536, respectively).

O'Malley and Jordan[134] reported a cost-utility analysis that used clinical data from a published study (Menon et al.[152]) of 100 open surgery and 500 robotic surgery prostatectomy patients. In this study, patients undergoing robotic prostatectomy had a shorter median duration of incontinence (1.47 months compared with 5.26 months), shorter median duration of erectile dysfunction (5.79 months compared with 14.46 months), and shorter mean length of hospital stay (three days compared with eight days). By adding the mean incremental costs for fixed capital, the robot maintenance contract, and disposables to the cost savings from the reduced length of hospital stay, the mean incremental cost for robotic surgery compared with open surgery was estimated to be $2,264.35 per patient. Using their judgment and estimations for calculating the expected values of the QALYs that may have resulted from better outcomes with robotic surgery, O'Malley et al. estimated an incremental gain of 0.093 QALYs with robotic surgery over one year, and reported an incremental cost-effectiveness ratio of $24,475.43/QALY for robotic surgery compared with open surgery.

Burgess et al.[135] retrospectively reviewed the costs and outcomes of 78 robot-assisted laparoscopic prostatectomy patients, 16 RRP patients, and 16 RPP patients. The mean operative time was statistically significantly higher in the robotic surgery group (262 minutes compared with 202 minutes for RRP, and 196 minutes for RPP; P = 0.001), and the mean blood loss was statistically significantly lower (227 mL compared with 1,015 mL for RRP, and 780 mL for RPP; P < 0.001). The mean length of hospital stay was comparable in the three groups. The mean operative charges were statistically significantly higher in the robotic surgery group ($25,443 compared with $16,552 for RRP and $16,320 for RPP; P = 0.001). The non-operative charges were comparable in the three groups. Because of higher operative charges, the total mean hospital charges were highest in the robotic surgery group ($39,315 compared with $31,518 for RRP and $29,771 for RPP; P < 0.001).

Scales et al.[136] compared the cost of RPP in specialist or community settings with the cost of robot-assisted radical prostatectomy. The estimates of costs and of lengths of hospital stay were obtained from the authors' institution and from the literature. Clinical outcomes were not considered. The average total hospital costs were highest in the robotic surgery group ($8,929 compared with $8,146 for open surgery in the community setting, and $8,734 for open surgery in the specialist setting). Although the robotic surgery group had lower room and board costs, these were offset by higher robotic equipment and supply costs and professional fees.

Guru et al.[137] reported differences in length of hospital stay and percent differences in hospital costs for patients undergoing robot-assisted prostatectomy and open prostatectomy. The mean length of hospital stay was shorter in the robotic surgery group (1.07 days compared with 2.40 days). The mean laboratory and supply costs were 37.3% and 171.98% higher, respectively, and pharmacy, recovery room, and ward care costs were 64.9%, 41.4%, and 50.0% lower, respectively, in the robotic surgery group. Overall, the total average costs were 2.39% lower in the robotic surgery group.

Lotan et al.[138] compared the costs of open prostatectomy, laparoscopic prostatectomy, and robot-assisted prostatectomy. The estimates for operating room time (open 160 minutes, laparoscopic 200 minutes, robotic 140 minutes) and length of hospital stay (open 2.5 days, laparoscopic 1.3 days, robotic 1.2 days) were obtained from the literature. The authors conducted analyses with the cost of the robot included and excluded (assuming donation) from the total costs. The average total costs in the open, laparoscopic, robotic (purchased), and robotic (donated) groups were $5,554, $6,041, $7,280, and $6,709, respectively. Higher costs in the robotic surgery groups were attributed to the purchase cost and maintenance cost of the robot, and to the cost of disposable equipment that was used for each surgical procedure.

In their comparison of robotic prostatectomy and open prostatectomy, Prewitt et al.[58] reported lower length of stay (LOS; 4.32 days compared with 2.57 days) and higher average direct per-patient costs ($9,579 compared with $5,911) in the robotic surgery group.

Cardiac Surgery

Bachinsky et al.'s[144] comparison of robotic HCR and OPCAB reported statistically significantly shorter length of hospital stay (4.6 ± 2.4 days compared with 8.2 ± 5.9 days; P = 0.04), fewer blood transfusions (7% compared with 57% of patients; P = 0.004), and fewer blood units transfused (0.2 ± 0.8 compared with 1.9 ± 1.8; P = 0.011) in the robotic group. The total hospital costs were higher in the robotic group ($33,401 per patient compared with $28,476 per patient).

The authors reported that postoperative costs were lower in the robotic group, but details were not provided.

Kam et al.[119] compared robotic MVR with conventional MVR and reported statistically significantly higher total procedure time (238.63 minutes compared with 201.76 minutes; P < 0.001), cardiopulmonary bypass time (126.37 minutes compared with 93.72 minutes; P < 0.0001), and aortic cross-clamp time (94.93 minutes compared with 73.14 minutes; P < 0.001) in the robotic group. The ICU stay was statistically significantly lower in the robotic group (36.66 minutes compared with 45.46 minutes; P = 0.002), as was LOS (6.47 days compared with 8.76 days; P < 0.001). Per-patient operative costs were higher in the robotic MVR group ($12,328 compared with $9,755) and postoperative costs were lower in the robotic MVR group ($6,174 compared with $8,124), with total per-patient hospital costs being higher in the robotic MVR group ($18,503 compared with 17,879).

Poston et al.'s[123] comparison of outcomes and costs for patients undergoing mini-CABG and OPCAB reported that the mean duration of surgery was statistically significantly higher in the mini-CABG group (5.8 ± 1.2 hours compared with 4.1 ± 0.9 hours; P < 0.001). The mean length of hospital stay, length of ICU stay, intubation time, intraoperative blood loss, number of red blood cell transfusion units, and number of major complications were all statistically significantly lower in the mini-CABG group. At one year, 4% of mini-CABG and 26% of OPCAB patients had experienced a major adverse cardiac and cerebrovascular event (hazard ratio 3.9, 95% CI 1.4 to 7.6; P = 0.0008). A larger proportion of mini-CABG patients reported a high level of satisfaction with the surgery (76.5% compared with 42.9%; P = 0.035), and return to work or normal activities was quicker with this group (44.2 ± 33.1 days compared with 93.0 ± 42.5 days; P = 0.016). The total average intraoperative costs for mini-CABG and OPCAB were $14,890 ± $3,211 and $9,819 ± 2,229 (P < 0.001), respectively, with this difference largely because of higher supply and operating room time costs in the mini-CABG group. The total average postoperative costs were higher in the OPCAB group ($6,361 ± $1,656 compared with $3,741 ± 1,214; P < 0.001), with this difference attributed mostly to higher ICU costs. The total average hospital costs in the mini-CABG and OPCAB groups were $18,631 ± $3,450 and $16,180 ± $2,777, respectively (P value not statistically significant); however, when the cost of the robot was added to the total average hospital costs in mini-CABG, the costs for the mini-CABG group increased to $23,398 ± $3,333 and were statistically significantly different from average total hospital costs for OPCAB (P = 0.001).

Morgan et al.'s.[145] costing analysis of patients undergoing ASD closure (robotic compared with sternotomy) and MVR (robotic compared with sternotomy) was performed with and without the cost of the robot included. In the ASD analysis, the mean intraoperative costs for robotic surgery patients and sternotomy patients were $8,457 ± 2,623 and $7,413 ± $2,581, respectively. Higher costs in the robotic surgery group were attributed mainly to higher operating room and supply costs. The mean postoperative costs for robotic surgery patients and sternotomy patients were $3,164 ± $656 and $3,237 ± $876, respectively. Patients in the robotic surgery group had lower mean ICU, laboratory, and room and board costs. The total average costs in the ASD analysis were $11,622 ± $3,231 for robotic surgery patients, and $10,650 ± $2,991 for sternotomy patients. The addition of the cost of the robot increased the total average cost per case in the robotic ASD group by $3,773. The relative costs in the MVR analysis were comparable. The mean intraoperative costs in the robotic surgery and sternotomy groups were \$10,999 ± \$1,186 and \$9,507 ± 1,598, respectively, with higher costs in the robotic surgery group also attributed to higher operating room and supply costs. The lower postoperative costs in the robotic surgery group (\$3,539 ± 839 compared with \$4,387 ± \$1,690) were attributable to lower drug, ICU, laboratory, and room and board costs. The total average costs in the MVR analysis were \$14,538 ± \$1,697 and \$13,894 ± \$2,774 for robotic surgery patients and sternotomy patients, respectively. The cost of the robot increased total average costs for the robotic MVR group by an additional \$3,444 per case.

Prewitt et al.[58] reported shorter LOS (4.33 days compared with 8.74 days) and lower average direct per-patient costs (\$14,160 compared with \$19,026) with robotic (compared with open) carotid arterial bypass.

Nephrectomy

Boger et al.'s[146] comparison of outcomes and costs in laparoscopic nephrectomy, hand-assisted laparoscopic nephrectomy, and robotic nephrectomy found no statistically significant between-group differences in estimated blood loss, operating room time, LOS, pain medication use, or complications. The mean total per-patient hospital costs in the laparoscopic, hand-assisted laparoscopic, and robotic surgery groups were \$10,635, \$12,823, and \$11,615, respectively.

Nazemi et al.'s.[115] comparison of the outcomes and costs of patients undergoing radical nephrectomy reported that the median operating time was highest in the robotic surgery group (354 minutes compared with 202 minutes for open surgery, 265 minutes for hand-assisted laparoscopy, and 237.5 minutes for laparoscopy; P = 0.02). The median estimated blood loss was highest in the open group (500 mL compared with 125 mL for robotic surgery, 100 mL for hand-assisted laparoscopy, and 125 mL for laparoscopy; P = 0.01). There were no statistically significant between-group differences in postoperative change in creatinine, postoperative drop in hemoglobin, blood transfusion, postoperative morphine use, and perioperative complication rate. The median hospital stay was shortest for the robotic surgery group (three days compared with five days for open surgery, four days for hand-assisted laparoscopy, and four days for laparoscopy; P = 0.03). Because of longer operating room times, the robotic surgery group had the highest operating room costs (\$10,252 compared with \$4,533 for open surgery, \$8,432 for hand-assisted laparoscopy, and \$7,781 for laparoscopy; P = 0.007), and the highest total hospital costs (\$35,756 compared with \$25,503 for open surgery, \$30,417 for hand-assisted laparoscopy, and \$30,293 for laparoscopy; P = 0.36).

Prewitt et al.[58] reported that patients undergoing robotic compared with open nephrectomy had shorter LOS (2.85 days compared with 5.58 days) and lower average direct costs (\$11,557 compared with \$12,359).

Hysterectomy

Barnett et al.'s[147] decision-analytic model used clinical parameter estimates obtained from the literature to compare the costs of robotic hysterectomy, open hysterectomy, and laparoscopic hysterectomy. The estimated per-patient total hospital costs for robotic surgery, open surgery, and laparoscopic surgery (with robot and maintenance costs included) were \$8,770, \$7,009, and \$6,581, respectively. The total per-patient hospital costs for the robotic group, with robot and maintenance costs excluded, were \$7,478. When the authors added the value of lost wages and caregiver costs, the per-patient costs for robotic hysterectomy, open hysterectomy, and laparoscopic hysterectomy were \$11,476, \$12,847, and \$10,128, respectively.

Halliday et al.[86] reported the results of a Canadian cost-consequences analysis of robotic hysterectomy compared with open hysterectomy. The authors reported that the robotic group had statistically significantly longer surgical time (351 ± 51 minutes compared with 283 ± 63 minutes; P = 0.0001), less blood loss (106 ± 113 mL compared with 546 ± 570 mL; P < 0.0001), greater uterine volume (120 ± 91 mL compared with 89 ± 102 mL; P < 0.05), less opioid use (one day or less, 50% compared with 4% [P = 0.0026]; three days or longer, 0% compared with 67% [P = 0.0001]), shorter time to tolerance of full diet in days (1.2 ± 0.4 compared with 3.5 ± 1.9; P < 0.0001), shorter LOS (1.9 ± 0.9 days compared with 7.2 ± 5.3 days; P < 0.0001), and fewer minor complications (19% compared with 63%; P = 0.003). The costs of the robot were included in the analysis, but the costs of the equipment, maintenance, and supplies were offset by the shorter length of hospital stay, so that total hospital costs were lower in the robotic group (\$9,613 ± 1,089 compared with \$11,764 ± \$6,790), assuming that five robotic cases would be performed per week.

Holtz et al.'s[96] cost-consequences analysis of robotic hysterectomy compared with laparoscopic hysterectomy found statistically significantly longer surgery time (192.5 ± 38 minutes compared with 156.2 ± 49 minutes; P = 0.03), and less blood loss (84.6 ± 32 mL compared with 150 ± 111 mL; P = 0.02) in the robotic surgery group. The length of hospital stay was the same in both groups (1.7 days). Higher operative, disposable equipment, and operating room time costs resulted in higher total hospital costs for the robotic group (\$5,084 ± \$938 compared with \$3,615 ± \$1,026).

In Pasic et al.'s[148] cost-consequences analysis of 1,661 robotic and 34,527 laparoscopic hysterectomies, data were obtained from a large administrative database. They reported longer (adjusted) surgery times in the robotic group (3.22 ± 0.52 hours compared with 2.82 ± 0.46 hours [inpatient]; 2.99 ± 0.48 hours compared with 2.46 ± 0.40 hours [outpatient]). Inpatient LOS was lower in the robotic group (1.37 ± 0.18 days compared with 1.49 ± 0.20 days). Adjusted total hospital costs were higher in the robotic group, for inpatients (\$9,640 ± \$1,640 compared with \$6,973 ± \$1,167) and for outpatients (\$7,920 ± \$1,082 compared with \$5,949 ± \$812).

Raju et al.'s[149] cost-consequences study of robotic hysterectomy, laparoscopic hysterectomy, and open hysterectomy reported clinical outcomes for the robotic group only. The mean operating time was 120 minutes (range 102 minutes to 220 minutes), average estimated blood loss was 30 mL (range 20 mL to 75 mL), LOS was one day, and all patients were able to return to work within two to three weeks of surgery. Estimated total hospital costs for the robotic, laparoscopic, and open surgery groups were £2,740, £2,323, and £2,678, respectively.

Wright et al.'s[150] abstract on the cost-consequences analysis of robotic surgery, laparoscopic surgery, and open surgery found fewer intraoperative complications (1.6% compared with 2.1% for laparoscopy and 7.8% for open) and longer operating time (267 minutes compared with 188 minutes for laparoscopy and 196 minutes for open surgery) in the robotic group. The shortest LOS was seen in the laparoscopic group (1.03 days compared with 1.35 days for robotic surgery and 3.35 days for open surgery). The total mean per-patient costs in the robotic, laparoscopic, and open surgery groups were $50,758, $41,436, and $48,720, respectively. Multivariate linear regression analysis confirmed a statistically significant independent effect of method of hysterectomy on LOS, complication rate, operative costs, and total costs. BMI was found to be the most important predictor of operative time and operative costs, regardless of surgical approach.

Sarlos et al.'s.[151] report on the perioperative outcomes and hospital costs for patients undergoing hysterectomy found that the operating room times of robotic surgeries were statistically significantly longer than those of laparoscopic surgeries (108.9 minutes compared with 82.9 minutes; $P < 0.001$). There were no statistically significant differences between groups in terms of complications, conversions to laparotomy, intraoperative bleeding, and hospital stay. The authors considered only material costs and personnel costs in their estimations of total average surgical costs. The total average surgical costs in the robotic surgery and laparoscopy groups were €4066.84 and €2150.76, respectively.

Bell et al.[102] reported on the operative and perioperative outcomes and costs of patients undergoing hysterectomy and lymphadenectomy for endometrial cancer staging. They found statistically significantly longer mean operative time in the robotic surgery group compared with the laparotomy group (184.0 ± 41.4 minutes compared with 108.6 ± 41.4 minutes; $P = 0.0001$), but not with the laparoscopy group (171.1 ± 36.2; $P = 0.14$). The estimated blood loss was lowest in the robotic surgery group (166.0 ± 225.9 cc compared with 316.8 ± 282.1 cc for laparotomy [$P = 0.01$], and 253.0 ± 427.7 cc for laparoscopy [$P = 0.25$]). The mean length of hospital stay was statistically significantly lower in the robotic surgery group compared with laparotomy (2.3 ± 1.3 days compared with 4.0 ± 1.5 days; $P = 0.0001$) but not with laparoscopy (2.0 ± 1.2 days; $P = 0.60$). Patients undergoing robotic surgery returned to normal activities more quickly than laparotomy patients (24.1 ± 6.9 days compared with 52.0 ± 71.8 days; $P < 0.0001$) and laparoscopy patients (31.6 ± 11.2; $P = 0.005$), and had fewer total complications (7.5% compared with 27.5% for laparotomy [$P = 0.015$] and 20% for laparoscopy [$P = 0.03$]). The total average direct costs (labour, pharmacy, supplies, room and board, depreciation) were lowest in the laparoscopy group ($5,564.00 ± $1,297.90), compared with the laparotomy group ($7,403.80 ± $3,310.60) and the robotic surgery group ($6,002.10 ± $733.90). The total average indirect (overhead) costs were lowest in the laparoscopy group ($2,005.80 ± $249.00) compared with laparotomy ($5,539.80 ± 2,589.30) and robotic surgery ($2,209.90 ± $417.70). The lost wages and household productivity in the laparotomy, laparoscopy, and robotic surgery groups were $7,540, $4,582, and $3,495, respectively.

b) Sensitivity analysis results

Six studies reported sensitivity analyses.[86,131,136,138,140,147]

Hohwü et al.[140] reported that their results were not affected by the parameters that were tested in the sensitivity analyses; however, the tested parameters and the sensitivity analysis results were not described.

Steinberg et al.[131] considered profit levels in a range of baseline annual caseloads and concluded that the purchase of a robot (compared with donation) requires greater case volume to maintain profits, at all levels of baseline productivity.

The model estimated by Scales et al.[136] was sensitive to changes in operative time, length of hospital stay, daily room costs, and case volume.

Lotan et al.[138] found that there was no decrease in length of hospital stay or operating room time that would make robotic surgery equivalent to open surgery in one-way analyses. Two-way analyses found that if robotic surgery were performed as an outpatient procedure, it would need to be performed in less than one hour to achieve cost equivalence with open surgery (base case operating room time for robotic surgery was 140 minutes). Robotic equipment costs would need to decrease to $500,000 and the annual maintenance contract would need to decrease to $34,000 to be cost equivalent to open surgery. An increase in caseload from 300 cases to 500 cases per year was insufficient for robotic surgery to achieve cost equivalence with open surgery or laparoscopic surgery.

In a hospital perspective analysis, Barnett et al.[147] found their model most sensitive to the costs of robotic disposable equipment, LOS, and operative time. In an analysis from a societal perspective, the model was most sensitive to the cost of disposable robotic equipment, and recovery time from robotic surgery.

Halliday et al.[86] found that between-group differences in per-patient total average hospital costs became statistically significantly different when the cost of the robot was not accounted for.

Ollendorf et al.[130] conducted sensitivity analyses but did not report results.

The study results are summarized in Tables A24 and A25 in Appendix 17.

5.2.4 Summary of economic review

Thirty studies[58,86,96,102,115,119,123,129-151] of robotic surgery compared with open surgery and laparoscopic surgery were reviewed. There was variability among studies in the study design, the costs included in the analyses, the treatment of robot costs, and the outcomes that were evaluated. Five of these studies were published in abstract form and therefore the information that was reported was limited. Most studies reflected the research question, and all but one were limited in their generalizability to a Canadian setting because they were conducted in different health care systems and because uncertainty was inadequately reflected in the analyses.

None of the economic evaluations reviewed for this report based the analyses on the results of randomized studies. Data for most studies were based on one centre evaluation or were obtained from literature review. Eight of the studies that reported patient characteristics[86,96,115,135,137,144-146] had small sample sizes, and seven studies[86,130,131,136,138,140,147] conducted sensitivity analyses.

Among the studies reporting clinical outcomes, the overall results suggest better outcomes in terms of blood loss and requirement for transfusion among patients undergoing robotic surgery, and the same or fewer complications, compared with open surgery.

Most studies that reported operating room time or costs reported them to be higher in the robotic surgery group compared with laparoscopic surgery and open surgery; however, the effect of the learning curve on robotic surgery times and outcomes was not accounted for in most studies. Lotan et al.[138] had restricted their data on operative times to a more current series in an effort to account for the impact of the learning curve on laparoscopic and robotic methods, and showed lower operative time costs in the robotic groups. Burgess et al.[135] also showed decreases in operative time costs when the learning curve had been overcome. A sub-analysis conducted in the clinical part of this technology assessment found no statistically significant differences in operative time between robotic prostatectomy and open prostatectomy when the learning curve in robotic surgery had been accounted for. In general, the length of hospital stay was shorter when robotic surgery was compared with open surgery, and was found to be longer or shorter than that of laparoscopic surgery, depending on the study. Four studies explored the impact of caseload on costs. Two of these studies[131,136] emphasized the importance of caseload in achieving the cost equivalence of robotic surgery compared with other surgical approaches; one study[86] explored the impact of doubling caseload from five to 10 cases per week on average costs, and found little difference in marginal costs compared with those of open surgery; and the authors of one study[138] reported that they could not achieve cost equivalence with higher caseloads.

Three prostatectomy studies reported lower total hospital costs in the robotic surgery group than in the comparator (open surgery) group; however, two of these studies[130,133] did not consider the cost of the robot, its maintenance, or disposables in the analysis, and the inclusion of robot costs was not specified in the third study.[142] Four cardiac surgery studies[119,123,144,145] reported higher average patient costs in the robotic group, and a fifth analysis reported higher costs with open surgery;[58] however, the inclusion of robot costs in the latter report was unclear. Among the nephrectomy studies, robotic surgery was more costly than laparoscopy and less expensive than hand-assisted laparoscopy in one report,[146] more costly than both comparators and open surgery in a second report,[115] and less costly than open surgery in a third report;[58] however, these three studies did not include robot costs,[146] or it was unclear whether they were included.[58,115] Among the hysterectomy studies, one study[102] reported that the total costs in the robotic surgery group were lower than in the laparotomy group and higher than those in the laparoscopy group, and one study[86] reported lower costs in the robotic (compared with open) group. Both these studies considered robot costs, with the latter study assuming a caseload of five surgeries per week. The remaining six studies in hysterectomy reported higher costs in the robotics group.

Four studies reported on the impacts of robotic surgery on productivity. The reporting of results was unclear in one study,[134] one study[123] reported statistically significantly quicker return to work and normal activities in robotic surgery patients undergoing CABG (compared with sternotomy), and two studies[102,147] reported lower lost productivity after hysterectomy performed with a robot, compared with laparoscopy or open surgery.

Three of the studies conducted cost-utility analyses, all in prostatectomy. One abstract[140] reported no difference in QALY gains after one year compared with open surgery, and no cost-utility estimate was therefore provided. One study reported that robotic surgery was cost-effective compared with open surgery (AUS$24,475.43 per QALY);[134] however, the method used to estimate QALYs in this study is unclear. The third cost-utility analysis[130] found robotic prostatectomy to be less costly and more effective than open surgery, but this analysis assumed maximal effectiveness while evidence for the superiority of robot-assisted prostatectomy was insufficient, and did not include the costs of the robotic equipment, its maintenance, or its consumable supplies in the model. A cost-effectiveness analysis in prostatectomy[140] reported a cost-effectiveness ratio of €64,343 per treatment success for robotic surgery compared with open surgery.

5.3 Primary Economic Evaluation: Methods

The clinical and economic reviews considered robotic surgery in four indications. When the protocol was written, a decision was made to select one of the four indications for a primary economic evaluation. The selection of the indication was to be made in consultation with the clinical experts for this report and was to consider incremental clinical evidence and the potential clinical and economic impact of robotic surgery based on the relative size of the eligible patient populations and utilization. While the clinical evidence on robotic prostatectomy did not suggest the greatest relative impact on patient outcome, and other indications also had sizable eligible patient populations, prostatectomy is the most frequently performed robotic surgical procedure in Canada (62% of all robotic procedures in 2010 [Danny Minogue, Minogue Medical Inc., Montreal, Quebec, Canada: personal communication, December 31, 2010]), and is performed at more Canadian centres (10 of 11) than any other robotic procedure. Given the frequency of use of robotic technology in prostatectomy in Canada, an economic evaluation of robotic surgery in this indication was considered to be appropriate.

5.3.1 Type of economic evaluation

The results obtained from the clinical review and meta-analyses did not show meaningful differences between RARP and ORP, or RARP and LRP, in mortality, general health-related quality of life, or return to normal activities. Differences were seen in urinary function at 12 months, sexual function at 12 months, and in positive margin rates in pT2 stage disease, in comparisons between RARP and ORP. The difference in complication rates between RARP and ORP approached statistical significance and was statistically significant when only procedures conducted after the learning curve were considered.

Sexual and urinary function are aspects of disease-specific quality of life (QOL), but data on the relative impact of surgical approaches on general health-related QOL are limited, and some clinicians have questioned whether observed differences between RARP and ORP are clinically meaningful.[153] One short-term observational study[53] using the 12-item Short Form Health Survey (SF-12) suggests that there is little difference between RARP and ORP, with physical component scores returning to baseline levels within six and seven weeks, respectively, and mental component scores exceeding baseline levels similarly in the two groups during follow-up. An abstract for a cost-utility analysis[140] that was described in the economic review reported no difference in QALYs after one year compared with open surgery. Observational studies in radical prostatectomy show that mean SF-12 and SF-36 scores approach or reach baseline levels within a year and remain at these levels for up to three and four years, even with sexual function and urinary function remaining low post-surgery.[154-156] A Canadian study that looked at utility and QOL in ORP patients using the Patient-Oriented Prostate Utility Scale (PORPUS) reported that QOL and utility values changed similarly over time, and that utility values approached baseline levels at 18 months to 30 months (baseline 0.94, 18 to 30 months 0.90, clinically important difference in PORPUS 0.05).[157] A second Canadian study in ORP patients who were administered the PORPUS-U[158] reported a mean baseline score of 0.97, and a mean one-year score of 0.94. Although surgery for prostate cancer may have impacts on urinary function and sexual function, it also simultaneously results in improvements in other QOL domains.[159] A Canadian study[160] assessed utility decrements attributed to sexual function and urinary function using four instruments (PORPUS-URS, PORPUS-USG, Health Utilities Index [HUI], and Quality of Well-Being Scale [QWB]). Estimating between-group differences (robotic surgery compared with open surgery) in QALYs using the utility estimates from this study and the sexual function and urinary function results from the clinical section of this report resulted in estimates of 0.01 to 0.02 QALYs, depending on the instrument. However, these estimates are based on observational data in which baseline sexual and urinary function were often not reported,[43,57,59] and where there were imbalances in several studies in terms of age,[43,57] follow-up,[39,59] and disease progression. Higher rates of non-localized prostate cancer among the open surgery groups were seen in most studies, with these differences being statistically significant in three studies.[45,54,59] In addition, none of the studies included in the analysis of the sexual function outcome controlled for the effects of medication for erectile dysfunction, which can differ by treatment group.[161] Data on comorbidity were generally lacking. Estimating between-group differences in urinary and sexual function beyond one year is difficult, given the lack of longer-term data on these outcomes in robotic prostatectomy, a decline in sexual function with age, and the use of medication and aids for erectile dysfunction.

Positive margin rates in pT2 stage disease after prostatectomy are predictors of disease recurrence in general; however, their impact in pT2 disease is less clear.[162,163] Given the low positive margin rates in pT2 stage disease and the estimated differences in these rates in ORP and RARP, the impact of RARP on overall disease recurrence will be small (0.71% over five years, assuming a large difference in recurrence rates between positive and negative margins in pT2 disease[164]). In Drouin et al.'s study,[79] 83% of patients had pT2 stage disease (the remainder being pT3), and the PSA recurrence rates among the three surgical approaches were the same at five years. The difference in complication rates in the RARP-ORP meta-analysis approached statistical significance, and attained statistical significance when only post–learning curve cases were considered, but a large proportion of these complications are minor and are often accounted for by transfusions of low blood volume. Based on the clinical data reviewed for this report, an estimated 25% of all complications in prostate surgery are major. Based on the complication rates in the clinical section of this report, the marginal difference in major complications between RARP and ORP would therefore be less than 1% for all cases, and 1.2% in cases that occur after the learning curve. The long-term impact of these possible differences is unclear. One study of more than 1,100 patients[55] that looked at readmissions and post-study visits for complications found no differences between patients who had undergone RARP and ORP.

Because clinically important between-group differences in survival, general QOL, morbidity, and potential disease recurrence could not be shown, a cost-minimization analysis was conducted. The results of this economic evaluation of robotic prostatectomy are presented in terms of average per-patient total and incremental costs for RARP compared with ORP and RARP compared with LRP.

5.3.2 Target population

The target population in this analysis is males with a diagnosis of prostate cancer for whom prostatectomy is the recommended therapy. The average age of patients in the clinical studies that were reviewed for this report is 61 years.

5.3.3 Comparators

RARP was compared with ORP and with LRP.

5.3.4 Perspective

Analyses were conducted from the perspective of the publicly funded health care system.

5.3.5 Effectiveness

Effectiveness in major patient outcomes is assumed to be equivalent between comparators.

5.3.6 Time horizon

Because the expected outcomes and treatment of patients could not be shown to differ after hospital discharge, the time horizon for this analysis is the length of hospitalization. The useful life of the robotic equipment was assumed to be seven years in the base case.

5.3.7 Modelling

Analyses were conducted in Microsoft Excel 2010, version 14.0, and in TreeAge Pro Suite 2009, version 1.0.2. Because analysis of the clinical data was conducted separately for RARP compared with ORP and for RARP compared with LRP, separate models were used for the RARP with ORP and RARP with LRP comparisons. Simple decision-analytic models (two treatment arms with no subsequent decision nodes) were constructed to compare costs by treatment group, and to conduct probabilistic sensitivity analyses on the incremental cost estimates. An internal validation of the models was conducted by varying model parameters to extreme values and assessing the feasibility of the resulting cost estimates.

5.3.8 Resource use and costs

Follow-up of patients post-discharge was assumed not to differ by surgical approach.

a) Surgical equipment and supplies

The da Vinci Si Surgical System is distributed in Canada through Minogue Medical Inc., and this distributor quoted costs of the system and its operation in US dollars (Danny Minogue, Minogue Medical Inc., Montreal, Quebec, Canada: personal communication, December 31, 2010). US prices were converted to Canadian prices using the average exchange rate in the previous year (US$1 is C$1.016, April 2010 to March 2011;[165] Table 16).

Table 16: Capital and Operating Costs of da Vinci Surgical System*		
Item	**US Dollars**	**Canadian Dollars**
da Vinci Si Surgical System	2,600,000	2,643,680
Start-up reusable equipment and accessories	200,000	203,360
Disposables and consumables (per procedure)	2,500	2,542
Training of surgeons† (each)	6,000	6,101
Training other personnel	Nursing and CPD in-service at no charge	
Annual maintenance (after first year warranty)	175,000	177,940

CPD = continuing professional development.
*Danny Minogue, Minogue Medical Inc., Montreal, Quebec, Canada: personal communication, December 31, 2010.
†Cost of training first four surgeons is included in the purchase price of the robot. Experience of Canadian centres suggests that after the first year, one new surgeon will be trained at each centre each year.

The undiscounted annual and cumulative costs to a centre for acquiring and operating this technology are shown in Appendix 18. Some costs of this technology are fixed (acquisition costs of robot), but others recur annually or vary by the number of procedures that are performed (maintenance contract, disposable and consumable equipment).

Initial capital expenditures were annuitized using the method described by Richardson and Gafni.[166] A discount of 5% was used. The base case assumptions for this estimation were that the useful life of the equipment is seven years, and that it has no residual value at the end of its use. The assumption about the useful life of equipment was based on convention in other studies of this technology (five or seven years) and on the fact that two Canadian centres have been operating their robotic equipment for seven years. Longer durations of use are possible, but technological change may limit the useful life of equipment. Based on the experience of Canadian centres, it was assumed that one new surgeon would receive the mandatory robotic training course provided by Intuitive Surgical, Inc., at each centre each year, after the first year. No other training costs were considered. Expenditures on training and maintenance over the life of the robot were discounted at 5%. Assuming an average caseload of 130 procedures per centre per year (the average number of procedures performed at 11 Canadian centres in 2010 [range 25 to 268]), the total cost of the robotic equipment in the base case was estimated to be C$7,427 per procedure.

The costs of supplies for laparoscopic prostatectomy and open radical prostatectomy were obtained from the literature[129] and were estimated to be C$831 and C$212 per procedure, respectively. Laparoscopic equipment was assumed to be disposable, and therefore there were no associated maintenance costs.

b) Hospital costs

No reliable national Canadian data were available on length of hospital stay among patients undergoing robotic prostatectomy (alone or in comparison with open prostatectomy or laparoscopic prostatectomy). As a result, comparative data on lengths of hospital stay that were obtained from the clinical review of this report were used. The per diem hospital costs were estimated from special tabulations obtained from the Canadian Institute for Health Information's Discharge Abstract Database for 2009-2010 (Sources: Canadian Institute for Health Information, Ottawa, Ontario, Canada. Discharge Abstract Database). Resource intensity weights were estimated for Canadian hospitalizations with procedure codes for radical prostatectomy, and then multiplied by the average cost per weighted case (CPWC) in Canadian hospitals. The CPWC for 2009-2010 data was unavailable when this report was written, and a 2008-2009 estimate, adjusted +3.5% to account for observed annual growth rates in CPWCs, was used. The estimated hospitalization cost was then divided by the average length of hospital stay that was estimated for radical prostatectomy patients, to provide a per diem cost. The estimated hospital per diem cost for prostatectomy was $2,353. The per diem costs were then multiplied by the average lengths of hospital stay estimated for the three surgical approaches in the meta-analyses.

c) Professional fees

Procedural surgical and anesthesia fees were obtained from the fee schedules of the four provinces performing robotic prostatectomy (British Columbia, Ontario, Quebec, and Alberta).[167-170] This represents a range of fee scale (low to high) seen in Canada and, taken together, 86% of the Canadian population. Surgeons who perform robotic prostatectomy bill the respective provinces for a laparoscopic procedure, because there are no unique billing codes for robotic prostatectomy. Using a weighted (by population) average, surgeon fees for open prostatectomy and for laparoscopic or robotic radical prostatectomy were estimated to be $1,022 and $1,381, respectively. The fees for anesthesia have a time component in three provinces: British Columbia, Ontario, and Quebec. Accounting for differences in operative times as reported in the meta-analyses, the weighted average fees for anesthesia in open surgery, laparoscopic surgery, and robotic surgery were $470, $615, and $581, respectively.

d) Transfusions

The probabilities of transfusion for each surgical approach were obtained from the results of the meta-analysis. In the comparison between RARP and ORP, these probabilities were 2.9% and 14.5%, respectively, and in the comparison between RARP and LRP, these probabilities were 2.5% and 4.6%, respectively. The number of red blood cell units transfused at each transfusion was estimated from the data on blood loss, which were obtained from the meta-analysis. It was assumed that up to 450 mL of lost blood would result in a transfusion with one unit of red blood cells. The cost of a unit of red blood cells in Canada was estimated from the literature to be $429.43.[171]

The costs that were reported in US dollars were converted to Canadian dollars using the average exchange rate of the year in which the costs were reported.[165] All costs are reported in 2011 Canadian dollars. The costs that were obtained from sources dating before 2011 were inflated using the Canadian Consumer Price Index.[172]

The health care resource use estimates and cost estimates that are used in this analysis are shown in Appendix 19, in Tables A27 and A28, respectively.

5.3.9 Discount rate

To estimate the present value of a procedure using robotic equipment with a specified lifespan, future costs were discounted at 5% per year in the base case. Rates of 0% and 3% were considered in the sensitivity analysis, as suggested by CADTH Guidelines.[128]

5.3.10 Variability and uncertainty

Sensitivity analyses were conducted on the estimated incremental costs of RARP compared with ORP, and RARP compared with LRP.

One-way and multi-way deterministic sensitivity analyses were conducted for key model parameters to assess the robustness of the base case results. The methods that were used to determine the parameter values for the sensitivity analysis included plausible ranges as determined by the variability of parameter estimates, the literature, guidelines, and expert opinion. For parameters with values that were most uncertain or for which variability was unknown, ranges of ± 50% of the estimated mean value were used.[173] The parameters that were included in the deterministic sensitivity analyses of the base case were:

- Discount and annuitization rate (0% and 3%)[128]
- Cost of robotic disposables and consumables (± 25%)[129]
- Cost of robotic annual maintenance contract (± 25%)[129]
- Cost of all recurring robotic costs (disposables, maintenance, training; ± 25%)
- Useful life of robot (five years and 10 years)
- Useful life of robot by average annual caseload (range of 50 to 500)
- Break-even number of procedures per year
- Donation of robotic equipment
- Exclusion of non-robotic equipment and supply costs
- Cost of non-robotic equipment and supplies (± 50%)
- Length of hospital stay (post–learning curve and marginal difference needed for break-even)
- CPWC (0% to 8%)
- Specialist fees (Quebec, Alberta)[169,170]
- Number of transfusions
- Complications (extreme cost scenario)
- Exchange rate (US$1 is C$0.85 to C$1.15, current exchange).

The donation of robotic equipment by a party lying outside the definition of the publicly funded health care system was considered as a scenario in the sensitivity analysis, because some Canadian centres have obtained a surgical robot in this manner.

One study of more than 1,700 patients[34] compared complications in RARP and ORP and reported that most of the statistically significant differences occurred among minor complications, and the only statistically significant difference among major complications was seen with pulmonary embolism (0.1% compared with 1.0% in RARP and ORP, respectively). According to data from the Canadian Institute for Health Information's Patient Cost Estimator, the cost of a hospitalization for pulmonary embolism in Canada is $6,010 (2008-2009 data. Sources: Canadian Institute for Health Information, Ottawa, Ontario, Canada. Discharge Abstract Database). Although it is likely that the impact of complications is captured in the base case model through LOS and transfusions, we assumed an extreme scenario in which all 25% of complications that are estimated to be severe, according to our clinical review, cost three times the average cost of a hospital stay plus professional fees ($34,445 for ORP and $24,726 for RARP) that were used in the base case model (Table 17).

Probabilistic sensitivity analyses using Monte Carlo simulation were conducted to estimate the uncertainty in incremental costs. The probabilities used in the model were assumed to follow a beta distribution. The length of hospital stay was assumed to follow a gamma distribution. Surgical equipment (including robot) costs were assumed to follow a fixed distribution, and all other health care costs were assumed to follow a gamma distribution, with standard errors being estimated at 50% of the mean. The distributions of estimates that were used in the models are shown in Tables A29 and A30 in Appendix 20. The uncertainty in the incremental total costs for each model was expressed in terms of 95% confidence intervals.

5.4 Primary Economic Evaluation: Results

5.4.1 Analysis and results

RARP compared with ORP

The estimated average costs of treatment in the RARP versus ORP comparison are shown in Table 17. The total average medical costs that were associated with RARP were C$15,682 per patient, and those that were associated with ORP were C$11,822 per patient (incremental costs C$3,860). The largest differences in mean per-patient costs were seen in robot costs (C$3,785), followed by hospital costs (C$3,714), costs of consumables and disposables (C$2,330), and robot maintenance costs ($1,064).

Table 17: Average and Incremental Per-patient Costs of RARP and ORP

Health Care Resource	RARP	ORP	Difference
Robotic equipment and accessories	$3,785	$0*	$3,785
Consumables and disposables	$2,542	$212	$2,330
Robot training course	$36	$0	$36
Robot maintenance contract	$1,064	$0	$1,064
Hospitalization	$6,279	$9,993	−$3,714
Surgical fees	$1,381	$1,022	$395
Anesthesia	$581	$470	$112
Transfusion	$12	$125	−$112
Total average costs	**$15,682**	**$11,822**	**$3,860**

ORP = open radical prostatectomy; RARP = robot-assisted radical prostatectomy.
Based on average caseload of 130 patients per year, and equipment life of seven years.
*Some equipment cost associated with open surgery is not accounted for by the consumables; however, this cost is not specific to prostatectomy, is allocated over many indications and procedures, and is likely to be small.

RARP compared with LRP

Table 18 shows the average and incremental per-patient costs for RARP compared with LRP. The total average per-patient costs for RARP and LRP were C$19,360 and C$14,735, respectively (incremental costs C$4,625). The largest differences in mean per-patient costs were seen in robot costs (C$3,785), hospitalization (C$1,929), consumables and disposables (C$1,711), and robot maintenance ($1,064).

Table 18: Average and Incremental Per-patient Costs of RARP and LRP			
Health Care Resource	**RARP**	**LRP**	**Difference**
Robotic equipment and accessories	$3,785	$0*	$3,785
Consumables and disposables	$2,542	$831	$1,711
Robot training course	$36	$0	$36
Robot maintenance contract	$1,064	$0	$1,064
Hospitalization	$9,959	$11,888	−$1,929
Surgical fees	$1,381	$1,381	$0
Anesthesia	$581	$615	$24
Transfusion	$11	$20	−$9
Total average costs	**$19,360**	**$14,735**	**$4,625**

LRP = laparoscopic radical prostatectomy; RARP = robot-assisted radical prostatectomy.
Based on average caseload of 130 patients per year, and equipment life of seven years.
*There is some equipment cost associated with laparoscopic surgery not accounted for by the consumables; however, this cost is not specific to prostatectomy, is allocated over many indications and procedures, and is likely to be small.

The average per-patient costs for RARP differ in the ORP and the LRP comparisons. This is because of differences in estimated average hospitalization costs. Hospital costs differed in the two comparisons because two different sets of studies were used to estimate lengths of stay, and their results differed. The differences in incremental lengths of stay and costs in the two comparisons are consistent with what might be expected clinically (smaller differences in length of stay with LRP than with ORP).

5.4.2 Results of uncertainty analysis

The results of the deterministic sensitivity analyses are shown in Table 19. The analysis found the base case estimates to be most sensitive to changes in the cost of consumable and disposable robotic equipment, the case where the robotic equipment was donated, the useful life of the robot, length of hospital stay, specialist fees (RARP compared with ORP only), and currency exchange rates.

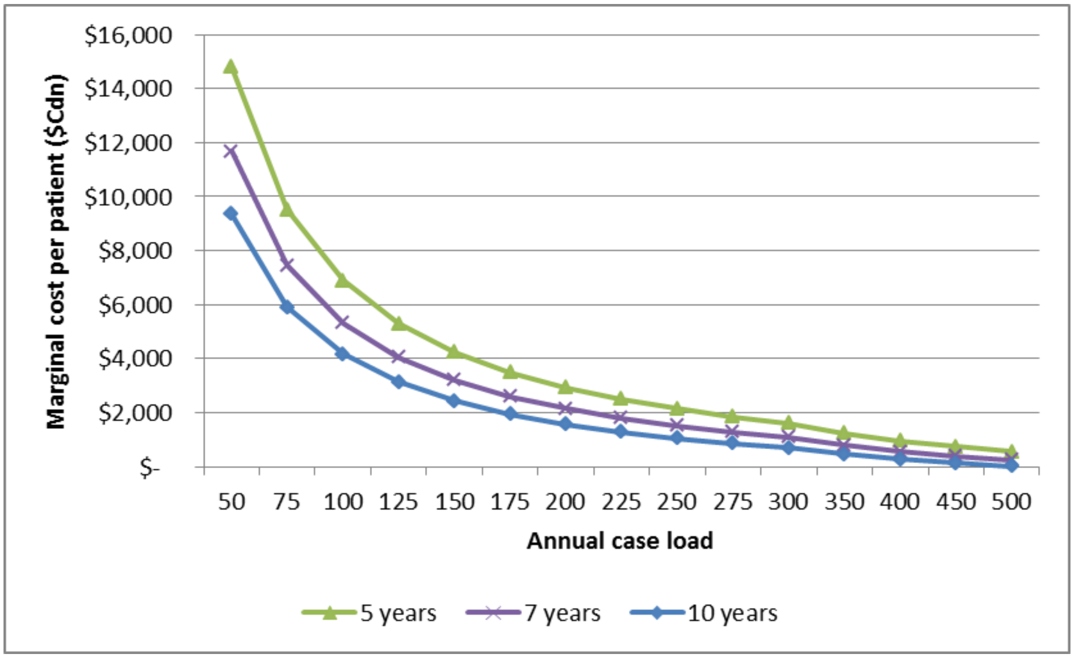
Table 19: Deterministic Sensitivity Analysis on Incremental Costs		
Scenario	**RARP Compared with ORP**	**RARP Compared with LRP**
Base case*	$3,860	$4,625
Discount-annuitization rate		
0%	$3,317	$4,081
3%	$3,634	$4,398
Robotic disposables and consumables		
–25%	$2,998	$3,763
+25%	$4,269	$5,034
Robot maintenance contract		
–25%	$3,594	$4,359
+25%	$4,127	$4,891
All recurring robot costs (disposables + maintenance + training)		
–25%	$2,950	$3,714
+25%	$4,771	$5,536
Robotic equipment donated	$76	$840

Table 19: Deterministic Sensitivity Analysis on Incremental Costs		
Scenario	**RARP Compared with ORP**	**RARP Compared with LRP**
Useful life of robot 5 years 10 years	 $5,061 $2,967	 $5,825 $3,731
Exclusion of non-robotic equipment and supplies costs	$4,072	$5,456
Non-robotic equipment and supplies −50% +50%	 $3,913 $3,807	 $5,040 $4,209
Number of procedures per year Break-even	 620	 2,450
Length of stay Post–learning curve Break-even (incremental days)	 $2,774 3.22	 Not applicable 2.79
CPWC adjustment from previous year +0% +8%	 $3,986 $3,699	 $4,650 $4,541
Specialist fees Quebec Alberta	 $3,604 $5,013	 $4,629 $4,658
Complications (extreme scenario) All procedures Post–learning curve only	 $3,489 $3,501	 Not applicable
Transfusions 2 units red blood cells per transfusion	 Not applicable	 $4,605
Exchange rate US$1= C$0.85 US$1 = C$1.15 Current (April 15, 2011) US$1 = C$0.962	 $2,642 $4,833 $3,461	 $3,406 $5,598 $4,225

CPWC = cost per weighted case; LRP = laparoscopic radical prostatectomy; ORP = open radical prostatectomy; RARP = robot-assisted radical prostatectomy.
*****Base case assumptions: caseload 130 procedures per year, robot life seven years, discount 5%.

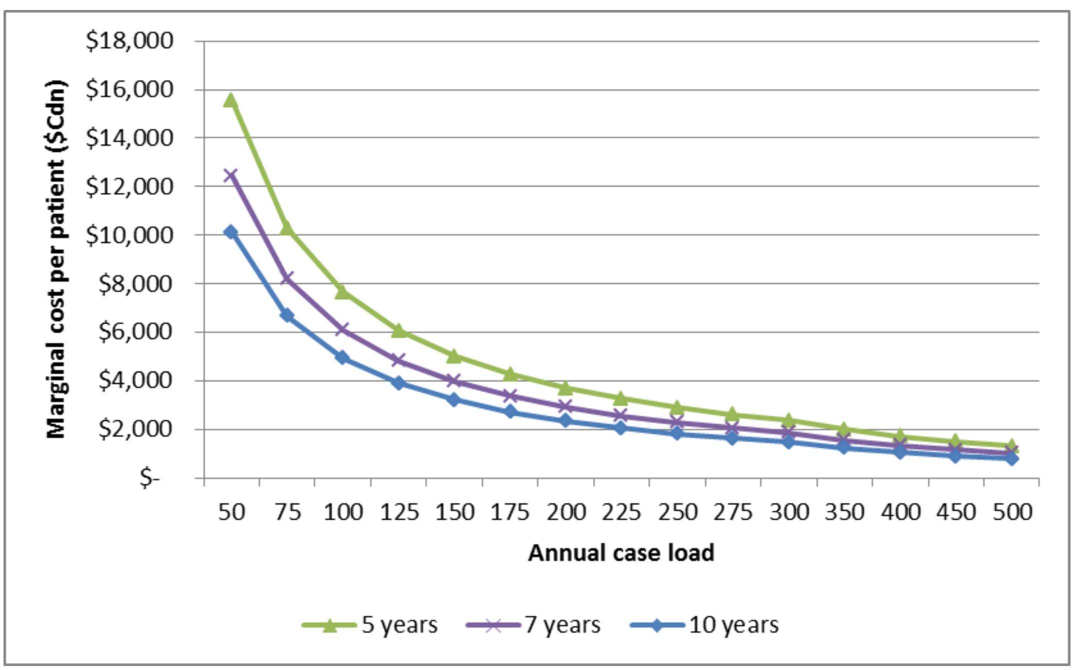
The results of the two-way sensitivity analysis on the number of procedures performed per year and the useful life of the robotic equipment are shown in Figures 40 and 41. The results show decreasing incremental costs with increasing caseload and with increasing equipment life. The mean incremental costs drop significantly during the first 200 procedures, with incremental costs at 200 procedures being between 17% and 24% of those estimated for 50 procedures, depending on the comparison and the duration of robot life. For the comparison of RARP with ORP, the incremental costs of RARP range from $11,677 per patient (50 procedures per year) to $245 per patient (500 procedures per year), assuming a seven-year robot life. With a 10-year robot life, the range of incremental costs is $9,354 to $13 per patient.

Figure 40: Incremental Cost per Patient of Robot-Assisted Radical Prostatectomy Compared with Open Radical Prostatectomy by Annual Caseload and Useful Life of Robot



In the comparison of RARP with LRP, the incremental costs of RARP range from $12,442 to $1,010 per patient (depending on annual caseload), assuming a seven-year robot life. With a 10-year robot life, the incremental costs range from $10,118 to $777 per patient.

Figure 41: Incremental Cost per Patient of Robot-Assisted Radical Prostatectomy Compared with Laparoscopic Radical Prostatectomy by Annual Caseload and Useful Life of Robot



In the probabilistic sensitivity analysis, the incremental cost of RARP when compared with ORP was estimated to be $3,809 (95% CI −$9,824 to $14,619), with RARP being more costly than ORP in 76% of simulations. When compared with LRP, the incremental cost of RARP was $4,573 (95% CI −$13,402 to $21,237), with RARP being more costly than LRP in 74% of simulations. In both comparisons, cost savings were largely attributable to variation in hospital costs.

5.4.3 Summary

Because the clinical review did not reveal clinically important between-group differences in major outcomes (mortality, morbidity, QOL, disease recurrence), a cost-minimization study was conducted to compare RARP with ORP and with LRP. Statistically significant differences were found in blood loss and blood transfusion (RARP compared with ORP and RARP compared with LRP), positive margin rates in pT2 stage disease (RARP compared with ORP), urinary and sexual function at 12 months (RARP compared with ORP), and complication rates (in post–learning curve procedures only). The general impact of these findings on major outcomes is likely to be small.

The results of this analysis showed RARP to be more expensive than ORP (incremental cost $3,860 per patient) and LRP (incremental cost $4,625). The cost of robotically performed surgery at an average Canadian centre was estimated to be $7,427; however, some savings are seen using this approach in terms of lower hospital costs as a result of reduced lengths of stay. The marginal costs of robotically performed surgery are also sensitive to currency exchange rates and increases in the cost of recurring expenses (consumables, maintenance). The incremental costs of RARP may be reduced by increasing caseload, with significant cost reductions seen in the first 200 cases. Longer durations of equipment life also reduce the incremental costs of RARP.

The cost of the robot that was included in this analysis is significantly higher than estimates reported in the studies that are reviewed in this report (approximately US$1.2 million), because the da Vinci Si Surgical System is a newer model and is the one that is available and being marketed. If this analysis had been carried out using the costs of the earlier model (such as those reported in Bolenz et al.[129]), the incremental cost of RARP (compared with ORP) would have been $1,740, and compared with LRP, the incremental cost of RARP would have been $2,504 (assuming a caseload of 130 and equipment life of seven years).

A benefit of using the robot is a potential saving on hospitalization costs because of reduced lengths of hospital stay. The results of the clinical review showed impacts on lengths of hospital stay in the comparison of robotically performed hysterectomy with open hysterectomy, and in cardiac surgery. Hysterectomy is the second-most frequently performed robotic procedure in Canada (23% of all procedures in 2010; Danny Minogue, Minogue Medical Inc., Montreal, Quebec, Canada: personal communication, December 31, 2010). Based on hospital cost data obtained from Canadian Institute for Health Information (Source: Canadian Institute for Health Information, Ottawa, Ontario, Canada. Discharge Abstract Database), and the estimated differences in LOS between these two surgical approaches, the marginal hospital stay savings gained from robotic hysterectomy compared with open surgery would be approximately $5,000 per patient. Few cardiac surgeries are performed in Canada using the da Vinci robot, but based on our estimations, potential savings in hospital stay costs gained from robotically performed cardiac procedures may be approximately $5,700 per patient, compared with open surgery.

6 HEALTH SERVICES IMPACT

6.1 Population Impact

The potential population impact of expanding robotic surgery in Canada was estimated using current data on the number of robotic procedures performed at 11 Canadian centres, and an estimate of the number of Canadian institutions that may be more likely to buy a robot. The numbers of robotic surgeries performed in 2010 with a da Vinci robot were obtained from the Canadian distributor of this technology (Danny Minogue, Minogue Medical Inc., Montreal, Quebec, Canada: personal communication, December 31, 2010). See Table 20.

Table 20: Surgeries Performed with da Vinci Robot at 11 Canadian Centres, 2010

Procedure	Number of Procedures	Distribution of Procedures
Cardiac		
Mitral valve repair	7	0.5%
Coronary artery bypass graft	72	5.0%
Other	0	0.0%
Total cardiac	79	5.5%
Gynecological		
Hysterectomy	329	23.0%
Other	39	2.7%
Total gynecological	368	25.7%
Urological		
Prostatectomy	889	62.1%
Nephrectomy	45	3.1%
Other	39	2.7%
Total urological	973	67.9%
Other surgery	11	0.9%
Total all indications	**1431**	**100.0%**
Average procedures per centre (± SD)	130 ± 77	
Minimum and maximum number of procedures per centre in 2010	(25; 268)	

SD = standard deviation.

By the end of 2010, the 11 centres had been operating robotics programs for an average of 4.2 years (range of one to eight years). A total of 1,432 procedures were performed in the eleven centres in 2010, an average of 130 ± 77 procedures per centre. Among the four indications that are considered in this assessment, prostatectomy was the most frequently performed (62.1% of all procedures), followed by hysterectomy (23.0% of all procedures), cardiac procedures (5.5% of all procedures), and nephrectomy (3.1% of all procedures). These four indications represented 93.7% of all surgeries performed using the da Vinci robot in Canada in 2010.

There was variation between centres in the types of surgeries performed, and for this analysis, it is assumed that the distribution of surgeries in Table 21 represents the distribution of surgeries that would be seen nationally if the number of robotics programs expands in Canada.

To estimate the number of centres that may adopt a robotics program using the da Vinci technology, two characteristics of centres that have adopted this program were considered. All 11 centres were teaching hospitals, and all were large facilities with a large capacity, as indicated by the number of hospital beds (average ± SD 740 ± 237, range 459 to 1,311).[174,175] The base case population of centres was therefore considered to be general university-affiliated hospitals of at least 400-bed capacity. In sensitivity analyses, we considered the possibility that hospitals with fewer beds (300 to 399) and large non-teaching hospitals might also adopt a robotics program. Higher average annual rates of surgery were also considered in sensitivity analyses. Data on the number of hospitals, teaching status, and their capacities were obtained from the Canadian Institute for Health Information[174] and the Quebec Ministry of Health and Social Services.[175] The number of centres that were identified using this approach is summarized in Table 21.

Table 21: Number of Potentially Eligible Centres for Robotics Program, by Hospital Teaching Status, Capacity, and Province

Hospital Characteristics		Province									
Status	**Beds**	**NS**	**NL**	**NB**	**QC**	**ON**	**MB**	**SK**	**AB**	**BC**	**Canada**
Teaching	300 to 399	0	1	0	2	2	0	2	1	1	9
	*400+**	*1*	*1*	*0*	*11*	*9*	*2*	*0*	*5*	*2*	*31*
	Total	1	1	0	13	11	2	2	6	3	40
Non-teaching	300 to 399	0	0	3	4	12	0	0	1	2	22
	400+	1	0	1	4	12	0	0	1	4	23
	Total	1	0	4	8	24	0	0	2	6	45
All hospitals		2	1	4	21	35	2	2	8	9	85

AB = Alberta; BC = British Columbia; MB = Manitoba; NB = New Brunswick; NL = Newfoundland and Labrador; NS = Nova Scotia; ON = Ontario; QC = Quebec; SK = Saskatchewan.
*Base case institution. Data on the number of hospitals, their teaching status, and their capacities obtained from the Canadian Institute for Health Information[174] and the Quebec Ministry of Health and Social Services.[175]

No hospitals in Prince Edward Island or in the Territories met the criteria for capacity. A total of 31 teaching hospitals in Canada had 400 or more beds, including the 11 teaching hospitals (three in Quebec, four in Ontario, three in Alberta, and one in British Columbia) that had adopted a robotics program by the end of 2010.

By applying the average number of surgeries performed in Canadian centres in 2010 (mean 130) and the distribution of types of surgeries to the number of eligible hospitals, we obtained an estimate of the number of patients who may have surgery performed with a da Vinci robot in Canada annually (Table 22).

Table 22: Potential Annual Population Impact (cases) for Robotic Surgery with da Vinci Robot, by Hospital Teaching Status and Capacity, and Procedure, Canada

Hospital Characteristics		Procedure					
Status	**Beds**	**Cardiac**	**Prostatec-tomy**	**Hysterec-tomy**	**Nephrec-tomy**	**Other**	**Total**
Teaching	300 to 399	64	727	269	36	74	1,170
	*400+**	*222*	*2,503*	*927*	*125*	*254*	*4,030*
	Total	286	3,229	1,196	161	328	5,200

Table 22: Potential Annual Population Impact (cases) for Robotic Surgery with da Vinci Robot, by Hospital Teaching Status and Capacity, and Procedure, Canada							
Hospital Characteristics		**Procedure**					
Status	**Beds**	**Cardiac**	**Prostatectomy**	**Hysterectomy**	**Nephrectomy**	**Other**	**Total**
Non-teaching	300 to 399	157	1,776	658	89	180	2,860
	400+	164	1,857	688	93	188	2,990
	Total	322	3,633	1,346	181	369	5,850
All hospitals		608	6,862	2,542	343	696	11,050

*Base case institution.

If we consider only the types of institutions that have bought robots (teaching hospitals with 400 or more beds), expansion of robotics programs to all 31 similar institutions may result in 4,030 surgeries being performed annually. The inclusion of smaller teaching hospitals may result in an additional 1,170 annual procedures, for a total of 5,200. If non-teaching hospitals were to adopt this technology, 5,850 procedures may be added, for a potential total of 11,050 procedures per year.

Tables A31 and A32 in Appendix 21 show the potential population impact of increasing the average caseload per centre to 268 procedures per year (the maximum number observed at a Canadian robotic centre in 2010) and to 365 procedures per year (one procedure per day).

These estimates assume current national practice patterns of using robotic technology. These patterns may change over time because of shifts in the distribution of procedures among indications, and uptake of this technology for new indications.

6.2 Budget Impact

Because the final budget holder for the payment of robotic equipment and its maintenance is a hospital, the budget impact of implementing the da Vinci robot technology was estimated from this perspective.

The base case scenario for this analysis was determined based on the experience of 11 Canadian robotic centres, standard practice in the treatment of capital costs, and guidelines for budget impact analyses. It was assumed that the average number of procedures per centre would be the average observed in 11 Canadian centres in 2010 (mean 130), and that the average life of a robot, and therefore the time horizon of the analysis, would be seven years. Sensitivity analyses were performed on both these variables. The unit costs for a current model of the da Vinci robot, disposables, training, and maintenance have been described (section 5.3.8, Table 16). The undiscounted annual and cumulative costs to a centre for acquiring and operating this technology are shown in Appendix 18. The estimated costs of disposable surgical equipment that is used in open and laparoscopic surgeries in each of the four indications were obtained from the literature (Table A33 in Appendix 22). All published cost estimates were translated into Canadian dollars, with costs adjusted to 2011 dollars using the Canadian Consumer Price Index.[172,176] As in the guidelines for conducting budget impact analyses,[177,178] there was no annuitization or discounting of costs.

Because the impacts on lengths of stay affect hospital budgets, and because robotic surgery was reported to reduce lengths of stay in each of the four indications (section 4.2), these potential savings to hospital budgets were considered in the analysis. An average cost per diem was estimated for each of the four indications, based on special tabulations provided by the Canadian Institute for Health Information (Source: Canadian Institute for Health Information [CIHI], Ottawa, Ontario, Canada. Discharge Abstract Database). Savings from reduced lengths of stay were estimated for an average patient, based on the distribution of types of procedures reported in the population impact analysis (section 6.1) and the distribution of open compared with laparoscopic surgeries in the selected indications in Canada (CIHI special tabulations). Savings were also considered for each indication to simulate an institution that specializes in one indication. The estimated incremental savings in hospital costs for each indication are shown in Table 23.

Table 23: Incremental Savings in Hospitalization Costs, by Indication

Procedure	Robotic Compared with Open	Robotic Compared with Laparoscopic
Prostatectomy	$3,714	$1,929
Hysterectomy	$4,999	$310
Cardiac surgery	$5,727	Not applicable
Nephrectomy	$5,758	$1,427

The weighted incremental savings in hospital costs resulting from robotic surgery for an average patient were estimated to be $3,150 per procedure. The weighted per-patient savings for prostatectomy were estimated to be $2,388; for hysterectomy, $4,546; and for nephrectomy, $3,653.

Table 24 summarizes the estimated discounted per-hospital budget impact of a robotics program for a Canadian average case, and for each of the four indications.

Table 24: Hospital Budget Impact of Robotic Surgery Program, by Indication and Useful Life of Equipment

Patient Population	Costs	Useful Life of Robotic Equipment		
		5 Years	7 Years	10 Years
	Robot costs	$5,235,503	$6,264,505	$7,808,007
Average patient	Other surgical disposables	$344,866	$482,812	$689,731
	Hospital stay savings	$2,047,732	$2,866,825	$4,095,464
	Net program costs	$2,842,905	$2,914,868	$3,022,812
Prostatectomy	Other surgical disposables	$436,516	$611,122	$873,031
	Hospital stay savings	$1,552,347	$2,173,285	$3,104,694
	Net program costs	$3,246,641	$3,480,097	$3,830,282
Hysterectomy	Other surgical disposables	$204,505	$286,307	$409,010
	Hospital stay savings	$2,955,069	$4,137,097	$5,910,139
	Net program costs	$2,075,929	$1,841,101	$1,488,858
Cardiac surgery	Other surgical disposables	$141,992	$198,789	$283,984
	Hospital stay savings	$3,716,066	$5,202,493	$7,432,133
	Net program costs	$1,377,445	$863,223	$91,890
Nephrectomy	Other surgical disposables	$642,406	$899,368	$1,284,811

Table 24: Hospital Budget Impact of Robotic Surgery Program, by Indication and Useful Life of Equipment				
Patient Population	Costs	Useful Life of Robotic Equipment		
		5 Years	7 Years	10 Years
	Hospital stay savings	$2,374,467	$3,324,253	$4,748,933
	Net program costs	$2,218,631	$2,040,884	$1,774,263

Assumption — average caseload of 130 patients per year. Per-patient savings for average patient and for each indication were estimated based on distribution of frequency of procedures, obtained from Minogue Medical Inc. (Danny Minogue, Minogue Medical Inc., Montreal, Quebec, Canada: personal communication, December 31, 2010) and the Canadian Institute for Health Information's Discharge Abstract Database.

Assuming an average of 130 procedures per year, the seven-year costs for acquiring and operating a da Vinci robot are C$6,264,505; the cost of surgical disposable equipment that would have been used with alternative surgical approaches is $482,812; and the savings to an institution from hospital stays are $2,866,825, with the net cost of the program being $2,914,868. If the life of the robot is extended to 10 years, the total cumulative robot costs increase to $7,808,007, and net program costs are $3,022,812. For all time horizons, net program costs were lowest for cardiac surgery, followed by hysterectomy and nephrectomy, and highest for prostatectomy. Two-way sensitivity analyses on annual caseload (range 50 to 500 cases) and the useful life of robotic equipment (five to 10 years) are shown in Tables A34 to A38 in Appendix 23. Net hospital costs decline with increasing caseload for all indications, regardless of the useful life of equipment. The results suggest that cardiac surgery provides the most potential savings to a robotics program, and based on these estimates, a robotic cardiac surgery program would break even at 195 and 142 procedures per year, assuming a robot life of seven and 10 years, respectively.

6.3 Planning, Implementation, Utilization, and Legal or Regulatory Considerations

6.3.1 Planning and implementation issues

Several sources were consulted to identify planning and implementation issues for robotic surgery programs in each of the four specified indications. First, a literature review was conducted. Second, the content of a series of presentations on planning and implementing a robotics program[179] was consulted. Information was also sought from the Canadian distributor of the robot, Minogue Medical Inc. Finally, two Canadian robotic centres were asked to comment on the literature review, and to identify any planning and implementation issues that were not addressed. Planning and implementation issues for robotic surgery programs in general (not specific to indications) are discussed.

Robotics program leadership: Several authors have stated the importance of leadership in setting up and directing a robotics program.[179-183] Patel[180] suggests that certain questions need to be answered to the satisfaction of the leadership team in determining whether a robotics program is to be implemented. These questions relate to the motivation for the program, the initial and long-term commitments and benefits, the suitability of surgical services for robotic technology, the expected learning curve and timeline for success, and the possibility for validation of the efficacy of outcomes. Steers et al.[181] suggest that a multidisciplinary group of champions (surgeons, nurses, administrators) be identified before the purchase of the robot, and that this group assess all components of a robotics program (for example, the surgical procedures to be performed, training, personnel, equipment, facilities, operational issues, research, finance, marketing). Dexter[179] emphasizes the importance of a physician champion who is technologically knowledgeable. Palmer et al.[183] suggest that implementing a robotics program requires a lead surgeon who will become proficient in the procedure to be performed using a robot, so that he or she can educate the public, patients, and other physicians on its benefits. A leadership team of personnel from nursing, administration, anesthesia, and technical support would also help the lead surgeon in planning and advancing the program.

Assembly and maintenance of a robotics surgery team: Steers et al.[181,184] describe a robotic surgical team that is labour intensive in terms of operating room personnel. This team includes at least two surgeons, a scrub nurse, and an anesthesiologist. Up to two assistants, who may be resident fellows, faculty members, or surgical technicians, may also be needed, and one scrub nurse may be insufficient at times. Additional secretarial and office staff may also be needed. The authors note that their robotics team consists of 16 individuals. The authors state that a dedicated team of surgeons and nurses is important when implementing a robotics program to avoid delays in starting time, turnover, and operative times. Palmer et al.[183] describe similar operating room personnel requirements, and state that efficiency and decreased learning time will be facilitated by a devoted, well-trained, and consistent team. Properly trained physician's assistants who remain constant throughout the program (as opposed to residents or fellows, who may change) may be important for the adoption and growth of a program.[180] The training and appointment of a dedicated robotics nurse specialist may make using the robotic equipment and running the program more efficient.[179,185]

Training of surgical staff: There are no training and credentialing standards for robotic surgeons.[186] The initial training of surgical staff generally involves travelling to the manufacturer (Intuitive Surgical, Inc.) or another training site in the United States, for a short course that usually lasts two to three days.[187,188] The course consists of lectures on the principles and engineering of the robot, training on stitching and tying principles, in vivo work with animals or cadavers, observing experienced surgeons, and completing three cases that are overseen by an experienced surgeon.[182,188] Thavaneswaran et al.[188] note that ongoing training requirements involve a commitment from surgeons acting as mentors, because a surgeon's first cases may take six to eight hours each. Steers et al.[181] emphasize that training in robotic surgery is needed beyond the initial short course, and that this cannot be underestimated. The learning curve for performing robotic surgery may vary depending on the procedure and prior surgical experience; however, it may be challenging in some cases, with as many as 200 to 250 procedures being required for surgeons to become as capable as with other surgical methods.[25,188] Patel[180] suggests that patient selection is a factor in the surgeon's learning curve, and that patient morphology, health status, and disease characteristics be considered in selecting cases for less experienced surgeons, to help facilitate a successful outcome after early procedures.

Training of members of robotics team: Training a robotics team before starting a series of robotically assisted cases is essential.[189-191] The manufacturer of the da Vinci robot also provides training for other staff members of the surgical team.[188,192] Team curriculum objectives are more focused on sterile draping, operating room arrangement, instrument interfaces with the surgical cart, and device maintenance.[182,187,190,191] Surgical team education directed toward technological cohesion is an aspect of the training.[187] With proper training in set-up of surgical equipment, there may be no need to add to operating room time.[193] Patel[180] recommends that between two and four teams of operating room personnel be trained, depending on the expected surgical volume, and Dexter[179] suggests that all team members have a back-up.

Accessibility to specialities: Dexter[179] notes that if the program lead is a surgeon from one speciality, this may affect access to other specialities, and so speciality schedules and expectations must be discussed before purchase of the robot. Advanced robotic training in some specialities may be limited, and safe surgical practice will depend on continued surgical volume after training.[186] Multi-specialty usage may increase patient volumes, thus improving the cost-effectiveness of the program.[180]

Operating room requirements: Minogue Medical Inc. (Danny Minogue, Minogue Medical Inc., Montreal, Quebec, Canada: personal communication, December 31, 2010) recommends a minimum operating room space of 400 square feet (37.16 square meters), and three dedicated 115V/20A electrical outlets. Steers et al.[181] describe operating room planning as including time and room availability, room size, room layout, availability of proper receptacles and circuits, imaging, and access to supplies. They note that an operating room of at least 562 square feet (52.2 m^2) is needed at their institution to accommodate the staff, the robot, the anesthesia cart, the table, and the three-dimensional projection system. They add that a dedicated room for robotic surgery is preferable, to avoid having to move the robot and risking damage. In addition, the authors emphasize that making modifications to procedures or technology that may reduce operative times and increase turnover is essential to the cost-effectiveness of the program. Examples include monitoring the percentage of gas in the carbon dioxide tank, warming equipment to prevent lens fogging, minimizing retrieval or changing of robotic instruments, and maintaining a backup supply of sterilized and ready instruments. Palmer et al.[183] emphasize the fact that keeping an adequate stock of certain surgical instruments is paramount, given the limited lifespan. They add that extra lenses and instruments are needed when dealing with potential malfunctions. Palmer et al. suggest that operating theatres of 700 to 720 square feet (65 m^2 to 67 m^2) are optimal to fit a robotic system and personnel comfortably.

Processing: One Canadian centre noted that processing surgical equipment must be included in planning and training, because it had experienced an issue wherein it did not have the correct set-up in processing and had inadequate equipment to manage cleaning the instruments. Correcting these issues required capital purchase and renovations to the processing department (Dr. Janice Stewart, Surgery and Women's Health, Rockyview General Hospital, Alberta Health Services, Calgary, Alberta, Canada: personal communication, June 4, 2010).

Monitoring outcomes: Measurable objectives for caseloads to be obtained over baseline volumes should be defined, and outcome measures specific to the procedure (for example, continence, potency, blood loss, analgesic requirements) should be assessed.[181] Steers et al.[181] also recommend quality assessment that includes patient satisfaction with surgery, performance over time against benchmarks (for example, morbidity, complications, length of stay) or other quality performance measures, and QOL instruments. Palmer et al.[183] state that individuals who are concerned about quality improvement in the program should have access to regular updates on efficiency, outcomes, and patient satisfaction; that this is especially important early in the program; and that recruiting a statistician may facilitate the review of this information.

Monitoring costs: Robot-assisted surgery is generally more costly than other surgical approaches, and represents a sizable financial investment to the institution. The cost of capital equipment, facility modifications, maintenance and repair, disposable instruments, training and recruitment, and operating room time should be monitored over time. Surgical volumes and lengths of stay are factors in assessing the cost-effectiveness of the robotics program from the perspective of the institution, and should also be monitored. Societal costs (for example, potential patient productivity gains) may also be considered.

Research: Steers et al.[181] suggest that using the robotic technology for some procedures underutilizes the equipment's full potential, and that academic centres should engage in research to take the use of this technology to the next level, thus widening applications and improving patient outcomes.

Partnering: A Canadian robotic centre noted that developing a partnership with another Canadian site that uses the robot had been an asset in implementation. The ability to send staff to a partner location for observation on room set-up and flow and having the robot coordinator from the partner centre attend their first surgery was invaluable (Dr. Janice Stewart, Surgery and Women's Health, Rockyview General Hospital, Alberta Health Services, Calgary, Alberta, Canada: personal communication, June 4, 2010).

6.4 Ethical Considerations

6.4.1. Efficiency compared with equity

The results of the economic evaluation and budget impact analysis in this report suggest that centres with large surgical volumes may be best suited to managing the acquisition and operating costs, and the training and personnel, needed for the efficient operation of this technology. This may restrict the use and access of this technology in smaller centres or in less populated regions with smaller surgical volumes.

7 DISCUSSION

7.1 Summary of Results

Clinical

Over the last decade, there has been a rapid uptake of robot-assisted laparoscopic surgery. Standard laparoscopic approaches to surgical procedures have improved patient care in some fields, such as cholecystectomy. For more complex operations, such as radical prostatectomy, a laparoscopic approach is associated with a long learning curve and is technically challenging for the surgeon.[194] Robot-assisted surgery has been reported to provide benefits to the patient and surgeon. This health technology assessment reviews the published literature on four types of robot-assisted surgery: radical prostatectomy, nephrectomy, hysterectomy, and cardiac cases. Many other robot-assisted surgeries have been reported, but we have limited the scope to these surgeries, because they encompass the most commonly performed procedures.

The clinical review of this technology assessment included 51 studies for the indication of prostatectomy,[29-79] 26 for hysterectomy,[80-105] 10 for nephrectomy,[106-115] and eight for cardiac surgery.[116-123] All studies used prospective or retrospective observational designs. Based on the interpretation of primary estimates from meta-analysis, the following observations were made: robot-assisted surgery was shown to reduce the length of hospital stay compared with open prostatectomy, laparoscopic prostatectomy, open hysterectomy, laparoscopic hysterectomy, and laparoscopic partial nephrectomy; blood loss and transfusion rates were reduced with robot-assisted surgery, compared with open prostatectomy, laparoscopic prostatectomy, and open hysterectomy; robot-assisted surgery reduced positive margin rate compared with open prostatectomy in pT2 patients, and reduced postoperative complication rates compared with open hysterectomy and laparoscopic hysterectomy; and robot-assisted surgery increased operative time compared with open prostatectomy and open hysterectomy, and reduced operative time compared with laparoscopic prostatectomy. All these differences, which were identified in the clinical review, were statistically significant. Findings on robot-assisted cardiac surgery are scarce, but seem to favour robot-assisted surgery in terms of length of hospital stay.
These observations were drawn from primary analyses of all data and include statistically significant findings. None of the evidence is derived from findings in gold standard randomized controlled trials (RCTs). Instead, it is drawn from a collection of observational studies of prospective and retrospective designs. RCTs conducted to verify these findings are warranted. Second, a persistent presence of statistically significant heterogeneity was associated with many meta-analyses in this review and did not appear to be associated with study quality or study design, and analyses based on other criteria, such as surgeon expertise, were not feasible; thus, residual confounding is a limiting factor. Furthermore, given the controversies in the meta-analysis of observational data and synthesis in the presence of unexplained heterogeneity, interpretations of pooled evidence need to be made carefully. In addition to pooled estimates, summaries of reported directions of intervention effectiveness and the associated levels of statistical significance were thus also provided in this report. Lastly, because there is likely to be uncertainty about the clinical relevance of differences between surgical approaches that were observed for clinical outcomes, such as differences in length of hospital stay and extent of blood loss, this aspect needs to be considered during decision-making.

In prostatectomy, the reduction in positive surgical margin rates will likely result in better cancer control outcomes and reduced secondary interventions for prostate cancer recurrence. Although these data are unavailable for RARP, the positive surgical margin rate can be extrapolated from open surgical data, because a positive surgical margin is a pathological measure and would be standardized. The shorter operating time for RARP compared with laparoscopic surgery can have an impact on surgical waiting lists. For example, if a surgeon can perform two RARPs compared with one laparoscopic surgery for an assigned operating day, the wait times will decline. Alternatively, if a surgeon can perform three open prostatectomies in the same time, then the wait lists may be adversely affected, lengthening the time a patient is on the wait list. The effect on surgical wait times has not been reported in this context.[195] The comparison of postoperative complications reveals no advantage to one surgical approach. Heterogeneity among the studies and the reporting techniques also makes it difficult to draw conclusions.

Initiating a surgical robotics program has been associated with a learning curve. The initial experience worldwide involved the transition from an open approach or a laparoscopic approach to RARP.[196-198] With RARP, several learning curve estimates have been published, ranging from a few cases to several hundred.[40,197,199-202] One difficulty in interpreting the literature on surgical learning curves is the definition of a learning curve. Proficiency in RARP can be measured using different variables, including operative time, blood loss, complications, length of hospital stay, positive surgical margins, cancer control, and surgeon comfort. While these are individually important, the learning curve for each outcome measure can differ.[40] There is no standard definition of the learning curve that is accepted in the surgical literature.[198]

A variety of ways to reduce the learning curve have been promoted for RARP or LRP, including mentoring of the novice surgeon by an experienced surgeon, mini-fellowship training, formal full fellowships, graduated responsibility during the procedures for trainees, and robotic team training.[203-206] The literature is limited regarding the demonstrable benefits of these interventions and approaches.

The concern about the learning curve includes complications that result from surgeon inexperience with the technique. Several authors have made recommendations about case selection during the learning curve, based on experience. These recommendations include selecting patients with prostate gland volume less than 60 cm^3,[207] lower BMI,[208] and less extensive disease.[209] Complications during the early Canadian experience have been documented[195] and these complications may counter any benefits provided by RARP in patient recovery, quality of life, and overall health. An organized, cautious approach to the implementation of surgical robotics programs in Canada must be considered. Because the outcomes of radical prostatectomy are related to surgeon experience,[210,211] the use of robots at regional or tertiary care hospitals in a “centre of excellence” is a potential model to be considered.

More partial nephrectomy for small renal masses are being performed because of the increasing discovery of incidental masses with the use of cross-sectional imaging. Partial nephrectomy is typically performed for small kidney tumours that are presumed to be renal cell carcinoma, with the goals of complete extrication of the tumour and maximal preservation of kidney function (nephron sparing). The operation is technically challenging, and increasingly, laparoscopic and robot-assisted approaches have been reported. The review of the literature did not identify any adequate comparative studies for OPN and RAPN. Few studies compare LPN with RAPN. A shorter hospital stay was observed for RAPN, but the data are otherwise inconclusive. This is likely a factor of the recent introduction of RAPN worldwide. The first reported series was published in 2005,[212] and the earliest paper suitable for this analysis was published in 2008.[106] Other considerations regarding RAPN need to be acknowledged, but do not appear in this HTA because of a lack of suitable data. First, RARP facilitates the ability of surgeons to perform more complex surgeries, compared with LPN. Thus, patients who may have needed an OPN or a radical nephrectomy are having successful RAPN. There are insufficient data to address this argument. Second, an aspect of nephron-sparing surgery is the warm ischemic time (WIT) that is a result of clamping the renal blood vessels to allow the surgeon to resect the mass. With longer WIT, the risk of renal injury increases, with a resultant loss of kidney function. Several reports suggest RARP shortens the WIT compared with LPN, but a statement about the impact on renal function cannot be made.

Limited data showed that robot-assisted hysterectomy shortened the length of hospital stay, and reduced blood loss and transfusion rates and postoperative complications compared with open surgery and laparoscopic surgery, but it took longer to perform than open surgery. Although robot-assisted cardiac surgery seems to provide for a shorter length of stay compared with non–robot-assisted surgery, the paucity of the data and the heterogeneity among trials precluded any conclusion.

Economic

In the economic review, there were 30 economic evaluations[58,86,96,102,115,119,123,129-151] of robotic surgery in the four indications: 15 in prostatectomy, four in cardiac surgery, two in nephrectomy, eight in hysterectomy, and one in multiple indications (prostatectomy, cardiac surgery, nephrectomy). There was variation between studies regarding their conclusions about the costs and cost-effectiveness of robotic surgery; however, there was also variation between studies in the estimation and inclusion of costs. The estimation of QALYs in three cost-utility studies in radical prostatectomy was unclear. Most studies had limitations in the reporting of methods and results, and the relevance of most studies to a Canadian setting was also limited. One Canadian analysis in hysterectomy suggests that robotic surgery may be less costly than open surgery if the robot is used for five surgeries per week.

Because of the frequency with which this procedure is performed in Canada, radical prostatectomy was chosen as the indication for the economic evaluation. A cost-minimization analysis was conducted because an impact of robotic radical prostatectomy on major outcomes was not found in the clinical review. Robotic radical prostatectomy had shorter lengths of stay than open prostatectomy and laparoscopic radical prostatectomy, thus reducing hospitalization costs; however, the estimated per-patient costs of the robotic technology were large, leading to higher net incremental total costs of robotic radical prostatectomy, compared with open (incremental costs $3,860 per patient) surgery and laparoscopic (incremental costs $4,625) surgery. Other factors affecting incremental costs were the useful life of the equipment, specialist fees, currency exchange rates, changes in recurring costs, and annual caseload. The probabilistic sensitivity analysis suggests that RARP is more expensive than ORP and LRP in approximately 75% of cases, and that cost-saving situations with robotic surgery would largely be due to a variation in hospitalization costs.

The population impact analysis suggests 4,030 patients could undergo robotic surgery with a da Vinci robot in Canada annually, if the number of centres operating a robot expands from 11 to 31 (assuming similar institutional characteristics and average caseloads to those using a robot now). Consideration of large non-teaching general hospitals or hospitals with smaller capacity would expand the number of potential robotic centres to 85, and the annual patient population to 11,050. Considering the reduced hospitalization costs that result from decreased lengths of stay in each of the four indications, the net institutional costs for operating a robotics program for seven years is estimated to be $2.9 million, assuming an average robotics case and an annual caseload of 130 patients per year. When considering indication-specific programs, cardiac surgery is estimated to be the least costly, with a net program cost of $0.9 million over seven years, and prostatectomy the most expensive, with a net program cost of $3.5 million over seven years.

7.2 Strengths and Weaknesses of this Assessment

The limitation of the clinical review of this report is a lack of prospective RCTs of robot-assisted compared with laparoscopic or open surgical approaches.[213] This analysis is based on mostly single-institution observational studies, which means that the level of evidence is not as robust as that of RCT data. More comparative studies assessing postoperative outcomes, such as sexual function and continence, are needed. Many outcomes showed heterogeneity across trials, but no apparent potential causes of heterogeneity — including trial quality, trial design, sample size, definition of outcomes, and surgeons' experience — adequately explained these differences. Reporting of the potential covariates, such as surgeon expertise, was not provided, or was provided in formats that precluded categorization of many of the studies with outcome data available, and thus the potential for sensitivity analyses was limited. Enhanced reporting of future studies with such information is needed; even in studies where data were provided, a lack of sufficient detail about factors such as surgeon expertise may result in the presence of residual confounding. For localized prostate cancer, no RCT has been published, and there are several potential reasons. In general, localized prostate cancer has a long natural history; thus, even with surgical intervention, survival is measured 10 years to 20 years later. As a result, no studies exist. The outcomes that are analyzed here reflect short-term variables that have been reported. Until long-term data become available, no further conclusions can be drawn beyond those outlined. Another reason for the lack of RCT data is the fact that surgeons go through a learning curve when a new technology is introduced into the operating room. Few surgeons, if any, are considered to be experts at open prostatectomy, laparoscopic prostatectomy, and robot-assisted prostatectomy. Thus, any comparative study would include the surgeon as a variable. This is a potential source of bias for an RCT.

As new technologies are introduced, results involving small numbers of patients, technical modifications, and learning curves are more likely to be accepted for publication in the medical literature. Many of the studies that provided the basis for this analysis represent early experiences with robot-assisted surgery and are being compared with open surgical techniques with which the surgeons have experience using. Some papers cited here compare surgical outcomes between RARP and open surgery featuring small numbers of patients during the learning curve for the surgeons.[29,61,72] A review on prostatectomy found that there was no evidence of publication bias by Begg's test or Egger's test.[214]

In Canada, most radical prostatectomies are performed via an open surgical approach. Thus, any advantages for robot-assisted surgery are weighed against open surgery outcomes and cost. For this HTA, the clinical data analyzed are not from Canadian centres and, as a result, potential sources of bias must be acknowledged (publication bias and patient selection bias).

The systematic review for the economic assessment was conducted in a rigorous manner. Most of the data used in the economic evaluation and the health services impact analyses were obtained from Canadian sources. Current data on the use of robotic equipment at all Canadian centres were made available. Analyses were provided in a disaggregated manner throughout the report, to allow for further assessment of the results. Sensitivity analyses were conducted throughout.

There were limitations in the estimation of the cost of training in the economic evaluation. Intuitive Surgical, Inc., requires surgeons who are training in robotic surgery with the da Vinci Surgical System to undergo its initial training program, and these costs were included in the economic evaluation. Their overall impact in the analysis was small. There are no similar requirements for laparoscopic surgery. Robotic surgery and laparoscopic surgery are associated with learning curves that require additional training and mentorship, and these costs are difficult to estimate and could not be captured in the analysis.

Lengths of stay and their between-group differences were estimated from meta-analyses of international studies, under the assumption that marginal differences in length of stay would reflect what might be seen in Canada. At the time of the analysis of the data for this report, CIHI did not yet have reliable data on lengths of stay for the robotically performed procedures that are considered in this report. These data will likely become more reliable in the future, as more robotic surgeries are performed, more current data become available, and estimation methods are refined.

Hospitalization cost estimates derived from CIHI data would necessarily include the cost of disposable surgical equipment. Because the classification of robotic surgeries in CIHI's Discharge Abstract Database is recent, identification and costing methods for robotic surgeries is incomplete, and it is unclear whether the cost of robotic disposables has been included in the hospitalization costs. The costs of disposables for open and laparoscopic surgeries are likely to be included, but because of the level at which these costs are allocated in the CIHI method, if any of these costs are included, they are likely allocated uniformly across all surgical approaches. This implies that all our current estimates of hospital costs, regardless of surgical approach, may include an averaged allocation of the cost of surgical disposables, and all hospitalization costs would therefore be inflated by this average amount. If robotic disposables are included in this amount, they likely do not contribute a large relative weight, because few robotic surgeries are performed. Accounting for the cost of disposables separately in the economic analyses implies some double counting of these costs, but the fact that all hospitalization costs are inflated by the same amount led to the decision to assess them separately in the base case analysis. A sensitivity analysis that removed these costs from the cost-minimization analysis in prostatectomy showed that they had little impact in the open surgery comparison, and some impact in the laparoscopic surgery comparison; however, they did not affect the conclusions. In the budget impact analysis, these costs are presented separately, to allow for calculation with and without their consideration. In the population impact analysis, the number of hospital beds was used as a characteristic to identify institutions that are likely to adopt this technology. Surgical volume may have been a better indicator, but these data were unavailable.

Finally, there may be benefits of robotic surgery that are difficult to evaluate and that were not included in the economic assessment, such as the ergonomics of robotic surgery and the potential impact on surgeon fatigue and performance.

7.3 Generalizability of Findings

The primary economic evaluation applied the clinical results on robotic surgery in radical prostatectomy to a Canadian health care setting. The methods that were used to conduct the analysis were valid, and the patient populations to which the results apply appear to be representative of the types of cases seen in Canadian settings. Because national hospitalization data on robotic surgery are still being developed, it is difficult to assess how the lengths of stay reported in the clinical section of this report compare with those of actual Canadian surgical cases. The health care service use and costs used in the economic evaluation and budget impact analysis came mainly from Canadian sources.

7.4 Knowledge Gaps

RCTs are needed for the evaluation of clinical outcomes in all surgical procedures. There are limited data on outcomes from the Canadian centres using the robot are available. The decision to conduct a cost-minimization analysis was based on the absence of evidence for between-group differences in major outcomes. General QOL data in prostatectomy (and for the other indications) for the selected surgical comparisons were limited, and more research in this area may be useful. Longer-term data on patient outcomes in robotic surgery are also needed.

8 CONCLUSIONS

Based on the evidence included in this technology assessment, robot-assisted surgery may have an impact on many clinical outcomes in patients undergoing prostatectomy, partial nephrectomy, or hysterectomy, and benefits vary between indications. Findings on robot-assisted cardiac surgery were scarce but tended to favour robot-assisted surgery in terms of length of hospital stay. Comparisons between the methods of surgery on survival rates and time to return to work were inconclusive, because of scarcity of evidence. However, given the limitations of the available evidence and uncertainty about the clinical relevance of the size of its benefits compared with the alternative approaches, decisions about the uptake of robot-assisted surgery are difficult and must be made carefully. Robotically performed surgery is costly compared with laparoscopic and open approaches. The investment made in acquiring this technology is large, and institutions that choose to adopt it should monitor costs and outcomes to maximize cost-effective use in their centre. To decrease costs, centres could maximize caseloads, consider keeping the robot operational for longer durations, if possible, and use the technology for multiple indications, particularly those with greater potential impact on patient outcomes and institutional cost savings.

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10 APPENDICES

Appendix 1: Canadian Licensing Information for the da Vinci System

Source: Health Canada. Medical Devices Active Licence Listing (MDALL) [database on the Internet].Ottawa: Health Canada; 2009. [cited 2010 Oct 4]. Available from: http://webprod.hc-sc.gc.ca/mdll-limh/start-debuter.do?lang=eng

Licence No.: 27856
Type: System

Licence Section		
Device Class	**First Issue Date**	**Licence Name**
4	2001-03-06	DA VINCI SURGICAL SYSTEM

Device Section		Identifier Section	
First Issue Date	**Device Name**	**First Issue Date**	**Device Identifier**
2005-06-17	DA VINCI SURGICAL SYSTEM - CONTROL FOR ENDOSCOPIC INSTRUMENT	2005-06-17	IS1000
		2005-06-17	IS1200
2005-06-17	DA VINCI SURGICAL SYSTEM - ENDOSCOPIC INSTRUMENTATION	2005-06-17	340077-02
		2005-06-17	400001
		2005-06-17	400003
		2005-06-17	400004
		2005-06-17	400006
		2005-06-17	400007
		2005-06-17	400011
		2005-06-17	400031
		2005-06-17	400033
		2005-06-17	400035
		2005-06-17	400036
		2005-06-17	400042
		2005-06-17	400048
		2005-06-17	400049
		2005-06-17	400092
		2005-06-17	400093
		2005-06-17	400121
		2005-06-17	400126
		2005-06-17	400127
		2005-06-17	400154
		2005-06-17	400155
		2005-06-17	400157
		2005-06-17	400178

		2005-06-17	400181
		2005-06-17	400183
		2005-06-17	400184
		2005-06-17	400189
		2005-06-17	400190
		2005-06-27	400192
		2005-08-11	400203
		2005-08-11	400204
		2006-03-08	400207
		2006-03-08	400208
		2006-07-20	400194
		2006-07-20	400209
		2007-01-09	400117
		2007-01-09	400139
		2007-01-09	400141
		2007-01-09	400142
		2007-01-09	400143
		2007-01-09	400145
		2007-01-09	400146
		2007-01-09	400176
		2007-01-09	400177
		2007-07-06	400215
		2007-07-06	400230
		2007-08-22	400249
		2008-04-02	400170
		2008-04-02	400179
2005-06-17	DA VINCI SURGICAL SYSTEM - ENDOSCOPIC STEREO VIEW	2005-06-17	311464
		2005-06-17	311465
		2005-06-17	370253-03
		2005-06-17	370254-03
		2005-06-17	370371-03
		2005-06-17	370496-01
		2005-06-17	370612
		2005-06-17	370613
		2005-06-17	VS1000
		2005-08-11	311481
		2005-08-11	311482
2005-06-17	DA VINCI SURGICAL SYSTEM - ENDOWRIST INSTRUMENT BIPOLAR FORCEPS	2005-06-17	400171
		2005-06-17	400172
		2005-10-20	400205
		2006-09-14	400214
		2007-08-22	400227
2005-06-17	DA VINCI SURGICAL	2005-06-17	400110

	SYSTEM - ENDOWRIST INSTRUMENT PRECISE BIPOLAR PYRAMID TIP		
2005-07-05	DA VINCI SURGICAL SYSTEM - ULTRASONIC INSTRUMENTS	2005-07-05	400083
		2005-07-05	400165
		2005-07-05	400169
		2005-07-05	400173
		2005-07-05	400174

Licence No.: 72338
Type: System

Licence Section		
Device Class	**First Issue Date**	**Licence Name**
4	2006-09-13	DA VINCI S SURGICAL SYSTEM

Device Section		Identifier Section	
First Issue Date	**Device Name**	**First Issue Date**	**Device Identifier**
2006-09-13	DA VINCI S SURGICAL SYSTEM - CONTROL FOR ENDOSCOPIC INSTRUMENTS	2006-09-13	IS2000
2006-09-13	DA VINCI S SURGICAL SYSTEM - ENDOSCOPIC INSTRUMENTATION	2006-09-13	420001
		2006-09-13	420003
		2006-09-13	420006
		2006-09-13	420007
		2006-09-13	420033
		2006-09-13	420036
		2006-09-13	420048
		2006-09-13	420049
		2006-09-13	420093
		2006-09-13	420110
		2006-09-13	420117
		2006-09-13	420121
		2006-09-13	420139
		2006-09-13	420141
		2006-09-13	420142
		2006-09-13	420143
		2006-09-13	420145
		2006-09-13	420146
		2006-09-13	420157
		2006-09-13	420170
		2006-09-13	420173
		2006-09-13	420174

		2006-09-13	420176
		2006-09-13	420177
		2006-09-13	420178
		2006-09-13	420179
		2006-09-13	420181
		2006-09-13	420183
		2006-09-13	420184
		2006-09-13	420189
		2006-09-13	420190
		2006-09-13	420192
		2006-09-13	420194
		2006-09-13	420203
		2006-09-13	420204
		2006-09-13	420207
		2006-09-13	420208
		2007-07-06	420209
		2007-07-06	420215
		2007-07-06	420230
		2007-08-22	420246
		2007-08-22	420249
2006-09-13	DA VINCI S SURGICAL SYSTEM - ENDOSCOPIC STEREO VIEW	2006-09-13	VS2000
2006-09-13	DA VINCI S SURGICAL SYSTEM - ENDOWRIST INSTRUMENT BIPOLAR FORCEPS	2006-09-13	420171
		2006-09-13	420172
		2006-09-13	420205
		2006-09-13	420214
		2007-08-22	420227
2006-09-13	DA VINCI S SURGICAL SYSTEM - SURGEON CONSOLE	2006-09-13	IS2000 SSC

Manufacturer*
Company ID: 114906
INTUITIVE SURGICAL INC.
950 Kifer Road
Sunnyvale, CA, US, 94086

Appendix 2: Literature Search Strategy

OVERVIEW	
Interface:	Ovid
Databases:	BIOSIS Previews 1989 to 2009 Week 47 Embase 1980 to 2009 Week 43 Ovid MEDLINE 1950 to October Week 4 2009 Ovid MEDLINE(R) In-Process & Other Non-Indexed Citations October 28, 2009 Other databases searched: CINAHL (in EBSCO) — Cumulative Index to Nursing & Allied Health Literature Note: Subject headings have been customized for each database. Duplicates between databases were removed in Ovid and in Reference Manager 11 database.
Date of Search:	October 30, 2009
Alerts:	Monthly search updates began November, 2009 and were running until project completion
Study Types:	Health technology assessments, systematic reviews, meta-analyses, randomized controlled trials; controlled clinical trials; observational studies, practice guidelines
Limits:	Human (non-animal), English or French language limits

SYNTAX GUIDE	
/	At the end of a phrase, searches the phrase as a subject heading
.sh	At the end of a phrase, searches the phrase as a subject heading
MeSH	Medical Subject Heading
fs	Floating subheading
exp	Explode a subject heading
*	Indicates that the marked subject heading is a primary topic
ADJ	Requires words are adjacent to each other (in any order)
ADJ#	Adjacency within # number of words (in any order)
.ti	Title
.ab	Abstract

.hw	Heading Word; usually includes subject headings and controlled vocabulary
.pt	Publication type
.mp	Keyword search: includes title, abstract, name of substance word, subject heading word and other text fields
.jw	Journal words: searches words from journal names
/su	Surgery
use b9o89	Limit search line to the Biosis Previews database
use emez	" Embase
use mesz	" MEDLINE
use prem	" MEDLINE In-Process & Other Non-Indexed Citations

MULTI-DATABASE SEARCH

#	Searches
	Concept: robotic surgery
1	Robotics/
2	Automation/ use mesz
3	Bionics/
4	robot*.ti,ab.
5	robot*.hw. use b9o89
6	((remote adj3 manipulat*) or (remote adj3 navigat*)).ti,ab.
7	((remote adj3 manipulat*) or (remote adj3 navigat*)).hw. use b9o89
8	(tele-manipulat* or telemanipulat* or telerobotic* or tele-robotic* or telesurger* or tele-surger* or telesurgical or tele-surgical or telepresence or (remote adj3 operation*) or (remote adj3 surger*) or (remote adj3 surgical procedure*) or surgicaltreatment*).ti,ab.
9	(tele-manipulat* or telemanipulat* or telerobotic* or tele-robotic* or telesurger* or tele-surger* or telesurgical or tele-surgical or telepresence or (remote adj3 operation*) or (remote adj3 surger*) or (remote adj3 surgical procedure*) or surgicaltreatment*).hw. use b9o89
10	(Da Vinci or davinci or (intuitive adj surgical)).ti,ab.
11	(Da Vinci or davinci or (intuitive adj surgical)).hw. use b9o89
12	or/1-11
	Concept: prostatectomy
13	exp Prostatectomy/
14	exp prostate surgery/

15 prostatic neoplasms/su

16 exp prostate tumor/su

17 (prostatectom* or prostatoseminovesiculectom* or LRP or RRP).ti,ab.

18 (prostatectom* or prostatoseminovesiculectom* or LRP or RRP).hw. use b9o89

19 ((prostate or prostatic) adj3 (remov* or excision* or surger* or operation* or extirpation* or procedure* or adenectom* or resection*)).ti,ab.

20 ((prostate or prostatic) adj3 (remov* or excision* or surger* or operation* or extirpation* or procedure* or adenectom* or resection*)).hw. use b9o89

21 (TURP or TURPs or TUVP or TUVPs or VLAP or VLAPs or TUEVP or TUEVPs or TUIP or TUIPs or TUMPT or TUMPTs or TEVAP or TEVAPs or TUEVAP or TUEVAPs or HOLRP or HOLRPs or HOLEP or HOLEPs or TUNA or TUNAs).ti,ab.

22 (TURP or TURPs or TUVP or TUVPs or VLAP or VLAPs or TUEVP or TUEVPs or TUIP or TUIPs or TUMPT or TUMPTs or TEVAP or TEVAPs or TUEVAP or TUEVAPs or HOLRP or HOLRPs or HOLEP or HOLEPs or TUNA or TUNAs).hw. use b9o89

23 ((transurethral or trans-urethral or transurethra or trans-urethra) and (ablat* or thermotherap* or prostate* or vaporesection* or electrovapori* or electroresection* or vapori* or coagulat* or resection*)).ti,ab.

24 ((transurethral or trans-urethral or transurethra or trans-urethra) and (ablat* or thermotherap* or prostate* or vaporesection* or electrovapori* or electroresection* or vapori* or coagulat* or resection*)).hw. use b9o89

25 or/13-24

Concept: hysterectomy

26 exp hysterectomy/

27 (hysterectom* or historectom* or panhysterectom* or pan-hysterectom* or panhistorectom* or pan-historectom* or colpohysterectom* or colpohistorectom* or colpo-hysterectom* or colpo-historectom*).ti,ab.

28 (hysterectom* or historectom* or panhysterectom* or pan-hysterectom* or panhistorectom* or pan-historectom* or colpohysterectom* or colpohistorectom* or colpo-hysterectom* or colpo-historectom*).hw. use b9o89

29 ((uterus or uteri or womb) adj3 (remov* or excision* or surger* or operation* or extirpation* or amputation* or adenectom* or resection*)).ti,ab.

30 ((uterus or uteri or womb) adj3 (remov* or excision* or surger* or operation* or extirpation* or amputation* or adenectom* or resection*)).hw. use b9o89

31 (TLH or LAVH or LSH or LAVHO).ti,ab.

32 (TLH or LAVH or LSH or LAVHO).hw. use b9o89

33 or/26-32

Concept: nephrectomy

34 Nephrectomy/

35	exp Nephrectomy/
36	(nephrectom* or nefrectom* or heminephrect* or heminefrect* or hemi-nephrectom* or hemi-nefrectom* or nephroureterectom* or nefroureterectom* or nephro-ureterectom* or nefro-ureterectom* or uninephrectom* or uninefrectom* or uni-nephrectom* or uni-nefrectom* or LLDN).ti,ab.
37	(nephrectom* or nefrectom* or heminephrect* or heminefrect* or hemi-nephrectom* or hemi-nefrectom* or nephroureterectom* or nefroureterectom* or nephro-ureterectom* or nefro-ureterectom* or uninephrectom* or uninefrectom* or uni-nephrectom* or uni-nefrectom* or LLDN).hw. use b9o89
38	((kidney* or renal* or nephro* or nephri* or nefro* or nefri*) adj3 (remov* or excision* or surger* or operation* or extirpation* or amputation* or adenectom* or resection*)).ti,ab.
39	((kidney* or renal* or nephro* or nephri* or nefro* or nefri*) adj3 (remov* or excision* or surger* or operation* or extirpation* or amputation* or adenectom* or resection*)).hw. use b9o89
40	or/34-39
	Concept: cardiac surgery
41	exp Coronary Artery Bypass/
42	Coronary Artery Bypass Graft/
43	(CABG or bypass surger* or coronary graft* or TECABG or MIDCAB or OPCAB or endoscopic coronar* or TECAB).ti,ab.
44	(CABG or bypass surger* or coronary graft* or TECABG or MIDCAB or OPCAB or endoscopic coronar* or TECAB).hw. use b9o89
45	((artery or coronary or aorticocoronar* or aortico-coronar* or surger*) adj3 (bypass or shunt or anastomos* or graft)).ti,ab.
46	((artery or coronary or aorticocoronar* or aortico-coronar* or surger*) adj3 (bypass or shunt or anastomos* or graft)).hw. use b9o89
47	Mitral Valve/su
48	Mitral Valve Insufficiency/su
49	Mitral Valve Prolapse/
50	Mitral Valve Stenosis/
51	Mitral valve/su
52	mitral valve repair/
53	(MVR or mitral valvuloplast*).ti,ab.
54	(MVR or mitral valvuloplast*).hw. use b9o89
55	((mitral valve or MV or mitral click-murmur syndrome* or systolic click-murmur syndrome* or mitral regurgitation or mitral incompetence or mitral insufficiency or mitral stenosis or mitral stenoses or left atrioventricular cardiac valve or left atrioventricular heart valve or left atrioventicular valve or bicuspid anterior cusp or

	bicuspid cardiac valve or bicuspid heart valve or bicuspid valve or bicuspid valvular anterior cusp or cuspis anterior valva mitralis or cuspis anterior valvae mitralis or mitral anterior cusp or mitral cardiac valve or mitral anterior cusp or mitral cardiac valve) adj3 (surger* or surgical procedure* or operation* or repair* or restor* or reconstruct*)).ti,ab.
56	((mitral valve or MV or mitral click-murmur syndrome* or systolic click-murmur syndrome* or mitral regurgitation or mitral incompetence or mitral insufficiency or mitral stenosis or mitral stenoses or left atrioventricular cardiac valve or left atrioventricular heart valve or left atrioventicular valve or bicuspid anterior cusp or bicuspid cardiac valve or bicuspid heart valve or bicuspid valve or bicuspid valvular anterior cusp or cuspis anterior valva mitralis or cuspis anterior valvae mitralis or mitral anterior cusp or mitral cardiac valve or mitral anterior cusp or mitral cardiac valve) adj3 (surger* or surgical procedure* or operation* or repair* or restor* or reconstruct*)).hw. use b9o89
57	Thoracic Surgery/
58	exp Cardiac Surgical Procedures/
59	exp Cardiovascular Surgical Procedures/
60	exp Thoracic Surgical Procedures/
61	exp Heart surgery/
62	cardiovascular surgery/
63	thorax surgery/
64	((thoracic or thorax or heart or cardiac or cardia or cardiovascular or cardio-vascular or cardio or myocardial or myo-cardial or chest or cardiothoracic or cardio-thoracic or coronary or aortocoronary or aorto-coronary) adj3 (surger* or surgical procedure* or operation* or resection* or bypass or fontan or cardiomyoplast* or cardio-myoplast* or massage or angioplast* or atherectom*)).ti,ab.
65	((thoracic or thorax or heart or cardiac or cardia or cardiovascular or cardio-vascular or cardio or myocardial or myo-cardial or chest or cardiothoracic or cardio-thoracic or coronary or aortocoronary or aorto-coronary) adj3 (surger* or surgical procedure* or operation* or resection* or bypass or fontan or cardiomyoplast* or cardio-myoplast* or massage or angioplast* or atherectom*)).hw. use b9o89
66	(cardiosurger* or cardio-surger* or pericardiocentesis or pericardietom*).ti,ab.
67	(cardiosurger* or cardio-surger* or pericardiocentesis or pericardietom*).hw. use b9o89
68	or/41-67
69	12 and (25 or 33 or 40 or 68)
70	(RALP or RALN or RALPN or RARP or RARRP or RLP).ti,ab.
71	(RALP or RALN or RALPN or RARP or RARRP or RLP).hw. use b9o89
	Results: robotic surgery and four indications (prostatectomy OR hysterectomy OR nephrectomy OR cardiac surgery)

72 or/69-71

Concept: Methodology filter: SRs, MAs, HTAs

73 meta-analysis.pt.

74 meta-analysis/ or systematic review/ or meta-analysis as topic/ or exp technology assessment, biomedical/

75 ((systematic* adj3 (review* or overview*)) or (methodologic* adj3 (review* or overview*))).ti,ab.

76 ((quantitative adj3 (review* or overview* or synthes*)) or (research adj3 (integrati* or overview*))).ti,ab.

77 ((integrative adj3 (review* or overview*)) or (collaborative adj3 (review* or overview*)) or (pool* adj3 analy*)).ti,ab.

78 (data synthes* or data extraction* or data abstraction*).ti,ab.

79 (handsearch* or hand search*).ti,ab.

80 (mantel haenszel or peto or der simonian or dersimonian or fixed effect* or latin square*).ti,ab.

81 (met analy* or metanaly* or health technology assessment* or HTA or HTAs).ti,ab.

82 (meta regression* or metaregression* or mega regression*).ti,ab.

83 (meta-analy* or metaanaly* or systematic review* or biomedical technology assessment* or bio-medical technology assessment*).mp,hw.

84 (medline or Cochrane or pubmed or medlars).ti,ab,hw.

85 (cochrane or health technology assessment or evidence report).jw.

86 (meta-analysis or systematic review).md.

87 or/73-86

Results for robotic surgery, four indications and SRs/MAs/HTAs filter

88 72 and 87

Concept: Methodology filter: RCTs

89 (Randomized Controlled Trial or Controlled Clinical Trial).pt.

90 Randomized Controlled Trial/

91 Randomized Controlled Trials as Topic/

92 Controlled Clinical Trial/

93 Controlled Clinical Trials as Topic/

94 Randomization/

95 Random Allocation/

96 Double-Blind Method/

97 Double Blind Procedure/

98 Double-Blind Studies/

99 Single-Blind Method/
100 Single Blind Procedure/
101 Single-Blind Studies/
102 Placebos/
103 Placebo/
104 Control Groups/
105 Control Group/
106 (random* or sham or placebo*).ti,ab,hw.
107 ((singl* or doubl*) adj (blind* or dumm* or mask*)).ti,ab,hw.
108 ((tripl* or trebl*) adj (blind* or dumm* or mask*)).ti,ab,hw.
109 (control* adj3 (study or studies or trial*)).ti,ab,hw.
110 (Nonrandom* or non random* or non-random* or quasi-random*).ti,ab,hw.
111 (allocated adj1 to).ti,ab,hw.
112 ((open label or open-label) adj5 (study or studies or trial*)).ti,ab,hw.
113 or/89-112

Results for robotic surgery, four indications and RCTs filter

114 72 and 113

Concept: Methodology filter: observational studies

115 epidemiologic methods.sh.
116 epidemiologic studies.sh.
117 cohort studies/
118 cohort analysis/
119 longitudinal studies/
120 longitudinal study/
121 prospective studies/
122 prospective study/
123 follow-up studies/
124 follow up/
125 followup studies/
126 retrospective studies/
127 retrospective study/
128 case-control studies/
129 exp case control study/
130 cross-sectional study/
131 observational study/

132 quasi experimental methods/

133 quasi experimental study/

134 (observational adj3 (study or studies or design or analysis or analyses)).ti,ab,hw.

135 (cohort adj7 (study or studies or design or analysis or analyses)).ti,ab,hw.

136 (prospective adj7 (study or studies or design or analysis or analyses or cohort)).ti,ab,hw.

137 ((follow up or followup) adj7 (study or studies or design or analysis or analyses)).ti,ab,hw.

138 ((longitudinal or longterm or (long adj term)) adj7 (study or studies or design or analysis or analyses or data or cohort)).ti,ab,hw.

139 (retrospective adj7 (study or studies or design or analysis or analyses or cohort or data or review)).ti,ab,hw.

140 ((case adj control) or (case adj comparison) or (case adj controlled)).ti,ab.

141 (case-referent adj3 (study or studies or design or analysis or analyses)).ti,ab,hw.

142 (population adj3 (study or studies or analysis or analyses)).ti,ab.

143 (descriptive adj3 (study or studies or design or analysis or analyses)).ti,ab,hw.

144 ((multidimensional or (multi adj dimensional)) adj3 (study or studies or design or analysis or analyses)).ti,ab,hw.

145 (cross adj sectional adj7 (study or studies or design or research or analysis or analyses or survey or findings)).ti,ab,hw.

146 ((natural adj experiment) or (natural adj experiments)).ti,ab,hw.

147 (quasi adj (experiment or experiments or experimental)).ti,ab,hw.

148 ((non experiment or nonexperiment or non experimental or nonexperimental) adj3 (study or studies or design or analysis or analyses)).ti,ab,hw.

149 (prevalence adj3 (study or studies or analysis or analyses)).ti,ab,hw.

150 organizational case studies.sh.

151 case series.ti,ab,hw.

152 case reports.pt.

153 case report/

154 case study/

155 (case adj3 (report or reports or study or studies or histories)).ti,ab,hw.

156 or/115-155

Results for robotic surgery, four indications and observational filter

157 72 and 156

Concept: Methodology filter: human studies

158 exp animals/

159 exp animal experimentation/

160 exp models animal/

161 exp animal experiment/

162 nonhuman/

163 exp vertebrate/

164 animal.po.

165 or/158-164

166 exp humans/

167 exp human experiment/

168 human.po.

169 or/166-168

170 165 not 169

Results for robotic surgery, four indications, SRs or RCT or Observational filter, and human filter

171 (88 or 114 or 157) not 170

Concept: Methodology filter: clinical practice guidelines

172 Guidelines as topic/

173 Guideline/

174 Practice guideline/

175 exp Consensus Development Conference/

176 Consensus Development.sh.

177 Health Planning Guidelines/

178 Practice Guidelines as Topic/

179 Clinical Protocols/

180 (Guideline or Practice Guideline or Consensus Development Conference).pt.

181 Standards.fs.

182 Practice Guideline/

183 Clinical Practice/

184 Clinical Protocol/

185 Health Care Planning/

186 (guideline* or standards or best practice).ti.

187 (guideline* or standards or best practice).hw. use b9o89

188 (expert consensus or consensus statement or consensus conference* or practice parameter* or position statement* or policy statement* or CPG or CPGs).hw. use b9o89

189 or/172-188

Results for robotic surgery, four indications and CPG filter

190 72 and 189

191 171 or 190

192 remove duplicates from 191

193 limit 192 to english language

194 limit 192 to French

195 194 or 193

Economic Literature Search Strategy

OVERVIEW	
Interface:	Ovid
Databases:	BIOSIS Previews 1989 to 2009 Week 47 Embase 1980 to 2009 Week 43 Ovid MEDLINE 1950 to October Week 4 2009 Ovid MEDLINE (R) In-Process & Other Non-Indexed Citations October 28, 2009 Note: Subject headings have been customized for each database. Duplicates between databases were removed in OVID as well as Reference Manager Version 11 database.
Date of Search:	October 30, 2009
Alerts:	Monthly search updates began November, 2009 and were running until project completion
Study Types:	Economic studies
Limits:	English or French language only
SYNTAX GUIDE	
/	At the end of a phrase, searches the phrase as a subject heading
.sh	At the end of a phrase, searches the phrase as a subject heading
MeSH	Medical Subject Heading
exp	Explode a subject heading
$	Truncation symbol, or wildcard: retrieves plural or variations of a word
*****	Indicates that the marked subject heading is a primary topic
ADJ	Requires words are adjacent to each other (in any order)

ADJ#	Adjacency within # number of words (in any order)
.ti	Title
.ab	Abstract
.hw	Heading Word; usually includes subject headings and controlled vocabulary
/su	Surgery
use b9o89	Limit search line to the Biosis Previews database
use emez	" Embase
use mesz	" MEDLINE
use prem	" MEDLINE In-Process & Other Non-Indexed Citations

MULTI-DATABASE SEARCH

#	Searches
	Concept: robotic surgery
1	Robotics/
2	Automation/ use mesz
3	Bionics/
4	robot*.ti,ab.
5	robot*.hw. use b9o89
6	((remote adj3 manipulat*) or (remote adj3 navigat*)).ti,ab.
7	((remote adj3 manipulat*) or (remote adj3 navigat*)).hw. use b9o89
8	(tele-manipulat* or telemanipulat* or telerobotic* or tele-robotic* or telesurger* or tele-surger* or telesurgical or tele-surgical or telepresence or (remote adj3 operation*) or (remote adj3 surger*) or (remote adj3 surgical procedure*) or surgicaltreatment*).ti,ab.
9	(tele-manipulat* or telemanipulat* or telerobotic* or tele-robotic* or telesurger* or tele-surger* or telesurgical or tele-surgical or telepresence or (remote adj3 operation*) or (remote adj3 surger*) or (remote adj3 surgical procedure*) or surgicaltreatment*).hw. use b9o89
10	(Da Vinci or davinci or (intuitive adj surgical) or Aesop or automated endoscopic system for optimal positioning).ti,ab.
11	(Da Vinci or davinci or (intuitive adj surgical) or Aesop or automated endoscopic system for optimal positioning).hw. use b9o89
12	or/1-11
	Concept: prostatectomy
13	exp Prostatectomy/

14	exp prostate surgery/
15	prostatic neoplasms/su
16	exp prostate tumor/su
17	(prostatectom* or prostatoseminovesiculectom* or LRP or RRP).ti,ab.
18	(prostatectom* or prostatoseminovesiculectom* or LRP or RRP).hw. use b9o89
19	((prostate or prostatic) adj3 (remov* or excision* or surger* or operation* or extirpation* or procedure* or adenectom* or resection*)).ti,ab.
20	((prostate or prostatic) adj3 (remov* or excision* or surger* or operation* or extirpation* or procedure* or adenectom* or resection*)).hw. use b9o89
21	(TURP or TURPs or TUVP or TUVPs or VLAP or VLAPs or TUEVP or TUEVPs or TUIP or TUIPs or TUMPT or TUMPTs or TEVAP or TEVAPs or TUEVAP or TUEVAPs or HOLRP or HOLRPs or HOLEP or HOLEPs or TUNA or TUNAs).ti,ab.
22	(TURP or TURPs or TUVP or TUVPs or VLAP or VLAPs or TUEVP or TUEVPs or TUIP or TUIPs or TUMPT or TUMPTs or TEVAP or TEVAPs or TUEVAP or TUEVAPs or HOLRP or HOLRPs or HOLEP or HOLEPs or TUNA or TUNAs).hw. use b9o89
23	((transurethral or trans-urethral or transurethra or trans-urethra) and (ablat* or thermotherap* or prostate* or vaporesection* or electrovapori* or electroresection* or vapori* or coagulat* or resection*)).ti,ab.
24	((transurethral or trans-urethral or transurethra or trans-urethra) and (ablat* or thermotherap* or prostate* or vaporesection* or electrovapori* or electroresection* or vapori* or coagulat* or resection*)).hw. use b9o89
25	or/13-24
	Concept: hysterectomy
26	exp hysterectomy/
27	(hysterectom* or historectom* or panhysterectom* or pan-hysterectom* or panhistorectom* or pan-historectom* or colpohysterectom* or colpohistorectom* or colpo-hysterectom* or colpo-historectom*).ti,ab.
28	(hysterectom* or historectom* or panhysterectom* or pan-hysterectom* or panhistorectom* or pan-historectom* or colpohysterectom* or colpohistorectom* or colpo-hysterectom* or colpo-historectom*).hw. use b9o89
29	((uterus or uteri or womb) adj3 (remov* or excision* or surger* or operation* or extirpation* or amputation* or adenectom* or resection*)).ti,ab.
30	((uterus or uteri or womb) adj3 (remov* or excision* or surger* or operation* or extirpation* or amputation* or adenectom* or resection*)).hw. use b9o89
31	(TLH or LAVH or LSH or LAVHO).ti,ab.
32	(TLH or LAVH or LSH or LAVHO).hw. use b9o89
33	or/26-32
	Concept: nephrectomy

34	Nephrectomy/
35	exp Nephrectomy/
36	(nephrectom* or nefrectom* or heminephrect* or heminefrect* or hemi-nephrectom* or hemi-nefrectom* or nephroureterectom* or nefroureterectom* or nephro-ureterectom* or nefro-ureterectom* or uninephrectom* or uninefrectom* or uni-nephrectom* or uni-nefrectom* or LLDN).ti,ab.
37	(nephrectom* or nefrectom* or heminephrect* or heminefrect* or hemi-nephrectom* or hemi-nefrectom* or nephroureterectom* or nefroureterectom* or nephro-ureterectom* or nefro-ureterectom* or uninephrectom* or uninefrectom* or uni-nephrectom* or uni-nefrectom* or LLDN).hw. use b9o89
38	((kidney* or renal* or nephro* or nephri* or nefro* or nefri*) adj3 (remov* or excision* or surger* or operation* or extirpation* or amputation* or adenectom* or resection*)).ti,ab.
39	((kidney* or renal* or nephro* or nephri* or nefro* or nefri*) adj3 (remov* or excision* or surger* or operation* or extirpation* or amputation* or adenectom* or resection*)).hw. use b9o89
40	or/34-39
	Concept: cardiac surgery
41	exp Coronary Artery Bypass/
42	Coronary Artery Bypass Graft/
43	(CABG or bypass surger* or coronary graft* or TECABG or MIDCAB or OPCAB or endoscopic coronar* or TECAB).ti,ab.
44	(CABG or bypass surger* or coronary graft* or TECABG or MIDCAB or OPCAB or endoscopic coronar* or TECAB).hw. use b9o89
45	((artery or coronary or aorticocoronar* or aortico-coronar* or surger*) adj3 (bypass or shunt or anastomos* or graft)).ti,ab.
46	((artery or coronary or aorticocoronar* or aortico-coronar* or surger*) adj3 (bypass or shunt or anastomos* or graft)).hw. use b9o89
47	Mitral Valve/su
48	Mitral Valve Insufficiency/su
49	Mitral Valve Prolapse/
50	Mitral Valve Stenosis/
51	Mitral valve/su
52	mitral valve repair/
53	(MVR or mitral valvuloplast*).ti,ab.
54	(MVR or mitral valvuloplast*).hw. use b9o89
55	((mitral valve or MV or mitral click-murmur syndrome* or systolic click-murmur syndrome* or mitral regurgitation or mitral incompetence or mitral insufficiency or mitral stenosis or mitral stenoses or left atrioventricular cardiac valve or left

atrioventricular heart valve or left atrioventicular valve or bicuspid anterior cusp or bicuspid cardiac valve or bicuspid heart valve or bicuspid valve or bicuspid valvular anterior cusp or cuspis anterior valva mitralis or cuspis anterior valvae mitralis or mitral anterior cusp or mitral cardiac valve or mitral anterior cusp or mitral cardiac valve) adj3 (surger* or surgical procedure* or operation* or repair* or restor* or reconstruct*)).ti,ab.

56 ((mitral valve or MV or mitral click-murmur syndrome* or systolic click-murmur syndrome* or mitral regurgitation or mitral incompetence or mitral insufficiency or mitral stenosis or mitral stenoses or left atrioventricular cardiac valve or left atrioventricular heart valve or left atrioventicular valve or bicuspid anterior cusp or bicuspid cardiac valve or bicuspid heart valve or bicuspid valve or bicuspid valvular anterior cusp or cuspis anterior valva mitralis or cuspis anterior valvae mitralis or mitral anterior cusp or mitral cardiac valve or mitral anterior cusp or mitral cardiac valve) adj3 (surger* or surgical procedure* or operation* or repair* or restor* or reconstruct*)).hw. use b9o89

57 Thoracic Surgery/

58 exp Cardiac Surgical Procedures/

59 exp Cardiovascular Surgical Procedures/

60 exp Thoracic Surgical Procedures/

61 exp Heart surgery/

62 cardiovascular surgery/

63 thorax surgery/

64 ((thoracic or thorax or heart or cardiac or cardia or cardiovascular or cardio-vascular or cardio or myocardial or myo-cardial or chest or cardiothoracic or cardio-thoracic or coronary or aortocoronary or aorto-coronary) adj3 (surger* or surgical procedure* or operation* or resection* or bypass or fontan or cardiomyoplast* or cardio-myoplast* or massage or angioplast* or atherectom*)).ti,ab.

65 ((thoracic or thorax or heart or cardiac or cardia or cardiovascular or cardio-vascular or cardio or myocardial or myo-cardial or chest or cardiothoracic or cardio-thoracic or coronary or aortocoronary or aorto-coronary) adj3 (surger* or surgical procedure* or operation* or resection* or bypass or fontan or cardiomyoplast* or cardio-myoplast* or massage or angioplast* or atherectom*)).hw. use b9o89

66 (cardiosurger* or cardio-surger* or pericardiocentesis or pericardietom*).ti,ab.

67 (cardiosurger* or cardio-surger* or pericardiocentesis or pericardietom*).hw. use b9o89

68 or/41-67

69 12 and (25 or 33 or 40 or 68)

70 (RALP or RALN or RALPN or RARP or RARRP or RLP).ti,ab.

71 (RALP or RALN or RALPN or RARP or RARRP or RLP).hw. use b9o89

Results: robotic surgery and four indications (prostatectomy OR hysterectomy OR nephrectomy OR cardiac surgery)

72 or/69-71

Concept: Methodology filter: economic

73 *Economics/

74 *Economics, Medical/

75 *Economics, Pharmaceutical/

76 exp "Costs and Cost Analysis"/

77 exp Health Care Costs/

78 exp decision support techniques/

79 economic value of life.sh.

80 exp models, economic/

81 markov chains.sh.

82 monte carlo method.sh.

83 uncertainty.sh.

84 quality of life.sh.

85 quality-adjusted life years.sh.

86 exp health economics/

87 exp economic evaluation/

88 exp pharmacoeconomics/

89 exp economic aspect/

90 quality adjusted life year/

91 quality of life/

92 exp "costs and cost analyses"/

93 cost containment.sh.

94 (economic impact or economic value or pharmacoeconomics or health care cost or economic factors or cost analysis or economic analysis or cost or cost-effectiveness or cost effectiveness or costs or health care cost or cost savings or cost-benefit analysis or hospital costs or medical costs or quality-of-life).sh.

95 health resource allocation.sh.

96 (econom$ or cost or costly or costing or costed or price or prices or pricing or priced or discount or discounts or discounted or discounting or expenditure or expenditures or budget$ or afford$ or pharmacoeconomic or pharmaco-economic$).ti,ab.

97 (cost$ adj1 (util$ or effective$ or efficac$ or benefit$ or consequence$ or analy$ or minimi$ or saving$ or breakdown or lowering or estimate$ or variable$ or allocation or control or illness or sharing or life or lives or affordabl$ or instrument$ or technolog$ or day$ or fee or fees or charge or charges)).ti,ab.

98	(decision adj1 (tree$ or analy$ or model$)).ti,ab.
99	((value or values or valuation) adj2 (money or monetary or life or lives or costs or cost)).ti,ab.
100	(qol or qoly or qolys or hrqol or qaly or qalys or qale or qales).ti,ab.
101	(sensitivity analys$s or "willingness to pay" or quality-adjusted life year$ or quality adjusted life year$ or quality-adjusted life expectanc$ or quality adjusted life expectanc$).ti,ab.
102	(unit cost or unit-cost or unit-costs or unit costs or drug cost or drug costs or hospital costs or health-care costs or health care cost or medical cost or medical costs).ti,ab.
103	(decision adj1 (tree$ or analy$ or model$)).ti,ab.
104	or/73-103
	Results for robotic surgery, four indications and economic filter
105	72 and 104
106	remove duplicates from 105
107	limit 106 to english language
108	limit 106 to French
109	108 or 107

Other Databases Searched

Cochrane Library Databases Issue 4 2009	Same MeSH, keywords, limits, and study types used as per MEDLINE search, with appropriate syntax used.
Centre for Reviews and Dissemination Databases (CRD) University of York 2009	Same keywords and date limits used as per MEDLINE search, excluding study types and Human restrictions.
Health Economic Evaluations Database (HEED) http://heed.wiley.com	Same keywords, and date limits used as per Medline search, excluding study types and Human restrictions. Syntax adjusted for HEED database. Syntax adjusted for HEED database

Grey Literature and Handsearches

Date of Search:	November 2009
Keywords:	da vinci, robot surgery, robotic surgery, intuitive surgerical, prostatectomy, hysterectomy, nephrectomy, cardiac surgery.
Limits:	No date limits applied

*** NOTE:** This section lists the main agencies, organizations, and websites searched**; it is not a complete list.** For a complete list of sources searched, contact CADTH (http://www.cadth.ca).

Health Technology Assessment Agencies

Alberta Heritage Foundation for Medical Research (AHFMR)
http://www.ahfmr.ab.ca

Agence d'Evaluation des Technologies et des Modes d'Intervention en Santé (AETMIS). Québec
http://www.aetmis.gouv.qc.ca

Canadian Agency for Drugs and Technologies in Health (CADTH)
http://www.cadth.ca

Centre for Evaluation of Medicines. Father Sean O'Sullivan Research Centre,
St. Joseph's Healthcare,Hamilton, and McMaster University, Faculty of Health Sciences. Hamilton, Ontario
http://www.thecem.net/

Centre for Health Services and Policy Research, University of British Columbia
http://www.chspr.ubc.ca/cgi-bin/pub

Health Quality Council of Alberta (HQCA)
http://www.hqca.ca

Health Quality Council. Saskatchewan.
http://www.hqc.sk.ca/

Institute for Clinical Evaluative Sciences (ICES). Ontario
http://www.ices.on.ca/

Institute of Health Economics (IHE). Alberta
http://www.ihe.ab.ca/

Manitoba Centre for Health Policy (MCHP)
http://www.umanitoba.ca/centres/mchp/

Ontario Ministry of Health and Long Term Care. Health Technology Analyses and Recommendations
http://www.health.gov.on.ca/english/providers/program/ohtac/tech/techlist_mn.html

The Technology Assessment Unit of the McGill University Health Centre
http://www.mcgill.ca/tau/

Therapeutics Initiative. Evidence-Based Drug Therapy. University of British Columbia
http://www.ti.ubc.ca

Health Technology Assessment International (HTAi)
http://www.htai.org

International Network for Agencies for Health Technology Assessment (INAHTA)
http://www.inahta.org

WHO Health Evidence Network
http://www.euro.who.int/HEN

Australian Safety and Efficacy Register of New Interventional Procedures – Surgical (ASERNIP-S)
http://www.surgeons.org/Content/NavigationMenu/Research/ASERNIPS/default.htm

Centre for Clinical Effectiveness, Monash University
http://www.med.monash.edu.au/healthservices/cce/

Medicare Services Advisory Committee, Department of Health and Aging
http://www.msac.gov.au/

NPS RADAR (National Prescribing Service Ltd.)
http://www.npsradar.org.au/site.php?page=1&content=/npsradar%2Fcontent%2Farchive_alpha.html

Institute of Technology Assessment (ITA)
http://www.oeaw.ac.at/ita/index.htm

Federal Kenniscentrum voor de Gezendheidszorg
http://www.kenniscentrum.fgov.be

Danish Centre for Evaluation and Health Technology Assessment (DCEHTA). National Board of Health
http://www.dihta.dk/

DSI Danish Institute for Health Services Research and Development
http://www.dsi.dk/engelsk.html

Finnish Office for Health Care Technology and Assessment (FinOHTA). National Research and Development Centre for Welfare and Health
http://finohta.stakes.fi/EN/index.htm

L'Agence Nationale d'Accréditation et d'Evaluation en Santé (ANAES). Ministere de la Santé, de la Famille, et des Personnes handicappés
http://www.anaes.fr/anaes/anaesparametrage.nsf/HomePage?ReadForm

Committee for Evaluation and Diffusion of Innovative Technologies (CEDIT)
http://cedit.aphp.fr/english/index_present.html

German Institute for Medical Documentation and Information (DIMDI). Federal Ministry of Health
http://www.dimdi.de/static/de/hta/db/index.htm

Health Service Executive
http://www.hebe.ie/ProgrammesProjects/HealthTechnologyAssessment

College voor Zorgverzekeringen/Health Care Insurance Board (CVZ)
http://www.cvz.nl

Health Council of the Netherlands
http://www.gr.nl

New Zealand Health Technology Assessment Clearing House for Health Outcomes and Health Technology Assessment (NZHTA)
http://nzhta.chmeds.ac.nz/

Norwegian Centre for Health Technology Assessment (SMM)
http://www.kunnskapssenteret.no/index.php?show=38&expand=14,38

Agencia de Evaluación de Tecnologias Sanitarias (AETS), Instituto de Salud "Carlos III"/ Health Technology Assessment Agency
http://www.isciii.es/htdocs/investigacion/Agencia_quees.jsp

Basque Office for Health Technology Assessment (OSTEBA). Departemento de Sanidad
http://www.osasun.ejgv.euskadi.net/r52-2536/es/

Catalan Agency for Health Technology Assessment and Research (CAHTA)
http://www.gencat.net/salut/depsan/units/aatrm/html/en/Du8/index.html

CMT - Centre for Medical Technology Assessment
http://www.cmt.liu.se/pub/jsp/polopoly.jsp?d=6199&l=en

Swedish Council on Technology Assessment in Health Care (SBU)
http://www.sbu.se/

Swiss Network for Health Technology Assessment
http://www.snhta.ch/about/index.php

European Information Network on New and Changing Health Technologies (EUROSCAN). University of Birmingham. National Horizon Scanning Centre
http://www.euroscan.bham.ac.uk

National Horizon Scanning Centre (NHSC)
http://www.pcpoh.bham.ac.uk/publichealth/horizon

NHS Health Technology Assessment /National Coordinating Centre for Health Technology Assessment (NCCHTA). Department of Health R&D Division
http://www.hta.nhsweb.nhs.uk

NHS National Institute for Clinical Excellence (NICE)
http://www.nice.org.uk
NHS Quality Improvement Scotland
http://www.nhshealthquality.org

University of York NHS Centre for Reviews and Dissemination (NHS CRD)
http://www.york.ac.uk/inst/crd

The Wessex Institute for Health Research and Development. Succinct and Timely Evaluated Evidence Review (STEER)
http://www.wihrd.soton.ac.uk/

West Midlands Health Technology Assessment Collaboration (WMHTAC)
http://www.publichealth.bham.ac.uk/wmhtac/

Agency for Healthcare Research and Quality (AHRQ)
http://www.ahrq.gov/

Dept. of Veterans Affairs Research & Development, general publications
http://www1.va.gov/resdev/prt/pubs_individual.cfm?webpage=pubs_ta_reports.htm

VA Technology Assessment Program (VATAP)
http://www.va.gov/vatap/

ECRI
http://www.ecri.org/

Institute for Clinical Systems Improvement
http://www.icsi.org/index.asp

Technology Evaluation Center (Tec). BlueCross BlueShield Association
http://www.bluecares.com/tec/index.html

University HealthSystem Consortium (UHC)
http://www.uhc.edu/

Health Economic

Bases Codecs. CODECS (COnnaissances et Décision en EConomie de la Santé) Collège des Economistes de la Santé/INSERM
http://infodoc.inserm.fr/codecs/codecs.nsf

Centre for Health Economics and Policy Analysis (CHEPA). Dept. of Clinical Epidemiology and Biostatistics. Faculty of Health Sciences. McMaster University, Canada
http://www.chepa.org

Health Economics Research Group (HERG). Brunel University, U.K.
http://www.brunel.ac.uk/about/acad/herg
Health Economics Research Unit (HERU). University of Aberdeen
http://www.abdn.ac.uk/heru/

Health Economic Evaluations Database (HEED)
http://heed.wiley.com

The Hospital for Sick Children (Toronto). PEDE Database
http://pede.bioinfo.sickkids.on.ca/pede/index.jsp

University of Connecticut. Department of Economics. RePEc database
http://ideas.repec.org

Search Engines

Google
http://www.google.ca/

Yahoo!
http://www.yahoo.com

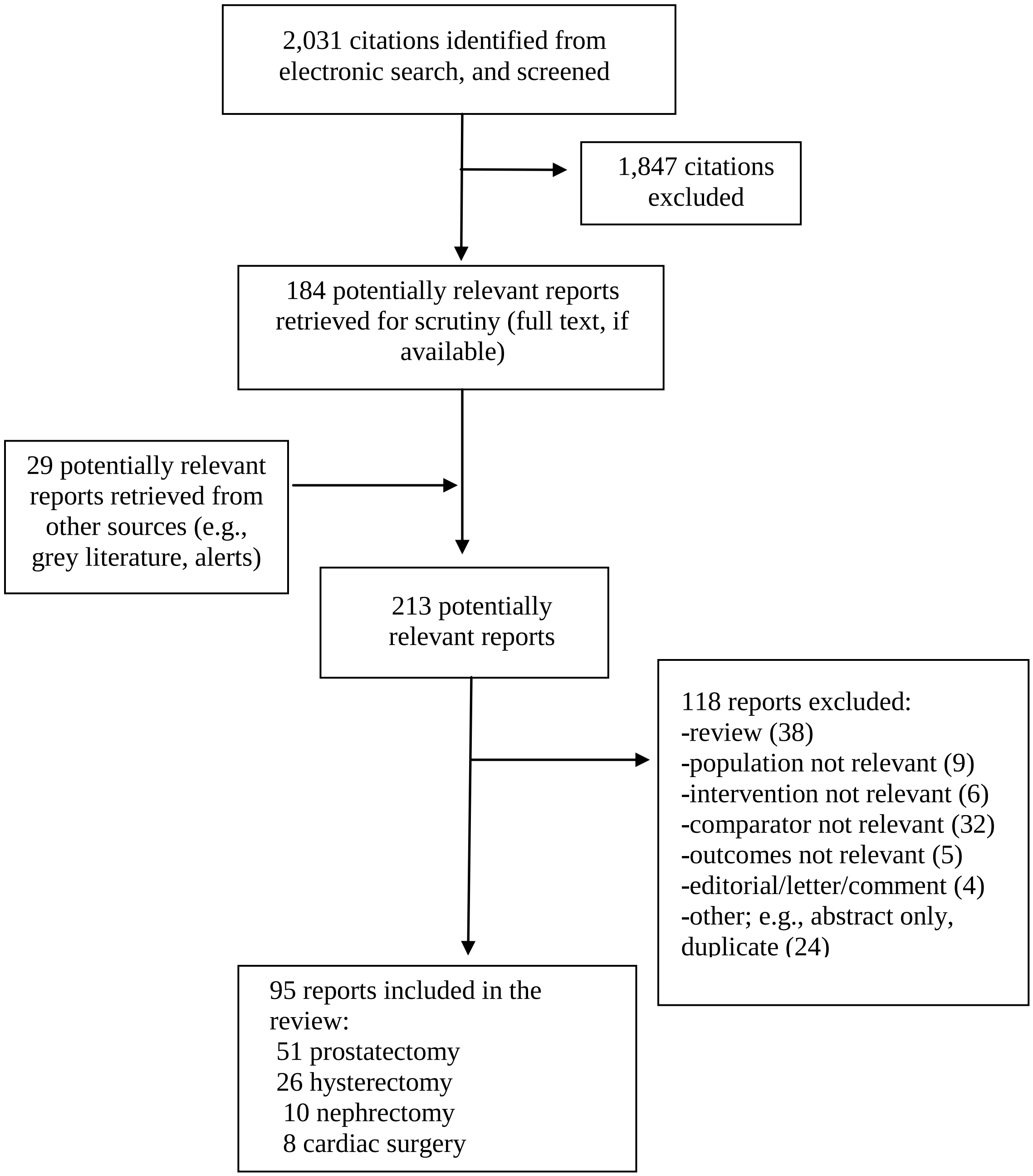
Appendix 3: Clinical Studies Assessment Form

<table>
<tr><td colspan="2">Reference   Reviewer</td></tr>
<tr><td></td><td>Score</td></tr>
<tr><td>Study design
1. Large RCT (At least 50 in each arm): 5 points
2. Small RCT: 3 points
3. Prospective: 2 points
4. Retrospective: 1 point

If RCT*:
- Randomization appropriately described?
- Blinded?
- Blinding appropriately described?
- Withdrawals described?
* An RCT gets full points if all 4 characteristics addressed. A half point is deducted for each characteristic is not addressed.</td><td></td></tr>
<tr><td>Study performance
1. Patient selection (methods of randomization/selection; equivalence of intervention & control)
2. Description/specification of the interventions
3. Specification and analysis of study (sample size; statistical methods; specification of outcomes)
4. Patient disposal (length of follow-up; dropouts; compliance failures)
5. Outcomes reported (fullness & clarity of reporting; missing results, statistical summary; conclusions consistent with data)

- Score (Info missing 0 point, Info limited 1 point, Info satisfactory 2 points)</td><td></td></tr>
<tr><td>Overall Score</td><td></td></tr>
<tr><td>Category
A (overall score 11.5-15.0): High quality – high degree of confidence in study findings
B (overall score 9.5-11.0): Good quality – some uncertainty regarding the study findings
C (overall score 7.5-9.0): Fair to good quality – some limitations that should be considered in any implementation of study findings
D (overall score 5.5-7.0): Poor to fair quality – substantial limitations in the study; findings should be used cautiously
E (overall score 1-5.0): Poor quality – unacceptable uncertainty for study findings</td><td></td></tr>
</table>

Appendix 4: Flow Chart of Selected Clinical Studies



Appendix 5: Excluded Studies for Clinical Review

Review Articles

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Editorial/Letter/Comment

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Appendix 6: Study Characteristics

Table A1: Study Characteristics

First Author, Year; Design	Country; No. of Centres; Funding	Comparison Arms	No. of Patients	No. of Surgeons	Length of Follow-up	Study Quality
Prostatectomy						
Ahlering, 2004;[29] Retrospective comparison	US; 1 centre; Funding NR	Da Vinci	60	Single surgeon for all	NR	C: fair to good quality
		Open radical prostatectomy	60			
Ball, 2006;[78] Prospective observational	US; 1 centre; Funding NR	Da Vinci	82	2	6 months	B: good quality
		Open radical prostatectomy	135	3		
		Laparoscopic radical prostatectomy	124	2		
Barocas, 2010;[30] Retrospective comparison	US; 1 centre; Funding NR	Da Vinci	1413	4	Median 8 months (IQR 2-20)	C: fair to good quality
		Radical retropubic prostatectomy	491	4	Median 17 months (IQR 8-34)	
Boris, 2007;[31] Retrospective comparison	US; 1 centre; Funding NR	Da Vinci	50	Single surgeon for all	Mean 12.2 months	C: fair to good quality
		Open radical retropubic prostatectomy	50		Mean 44.4 months	
		Open radical perineal prostatectomy	50		Mean 27.7 months	
Breyer, 2010;[32] Prospective observational	US; 1 centre; Funding NR	Da Vinci (3-arm system)	293	Several	≥ 12 months	C: fair to good quality
		Open radical prostatectomy	695	Several		
Burgess, 2006;[33] Retrospective comparison	US; 1 centre; Funding NR	Da Vinci (3-arm system)	78	Single surgical team for all	NR	C: fair to good quality
		Retropubic radical prostatectomy	16			
		Perineal radical prostatectomy	16			

Table A1: Study Characteristics						
First Author, Year; Design	**Country; No. of Centres; Funding**	**Comparison Arms**	**No. of Patients**	**No. of Surgeons**	**Length of Follow-up**	**Study Quality**
Carlsson, 2010;[34] Prospective observational	Sweden; 1 centre; Funding from gov't and other foundations	Da Vinci (5-trocar technique)	1253	6	Median 19 months	C: fair to good quality
		Open radical retropubic prostatectomy	485	9	Median 30 months	
Chan, 2008;[35] Retrospective comparison	US; 1 centre; Funding NR	Da Vinci (5-port technique)	660	2	NR	C: fair to good quality
		Open radical prostatectomy	340	3		
Chino, 2009;[36] Retrospective comparison	US; 1 centre; Funding NR	Da Vinci	368	NR	≥ 6 months	C: fair to good quality
		Open radical prostatectomy (retropubic or perineal)	536	NR		
Coronato, 2009;[37] Retrospective comparison	US; multicentre; Funding NR	Da Vinci	98	2	NR	D: poor to fair quality
		Open radical retropubic prostatectomy	57	1		
		Open radical perineal prostatectomy	41	1		
D'Alonzo, 2009;[38] Retrospective comparison	US; 1 centre: No industry funding	Da Vinci	256	7	≥ 3 months	C: fair to good quality
		Radical retropubic prostatectomy	280	8		
Di Pierro, 2011;[39] Prospective observational	Switzerland; 1 centre; No industry funding	Da Vinci	75	1	12 months	C: fair to good quality
		Open radical prostatectomy	75	3		
Doumerc, 2010;[40] Prospective observational	Australia; 1 centre; Gov't grant	Da Vinci (6-port technique)	212	Single surgeon for both	Mean 11.2 months± 9.4 (SD)	C: fair to good quality

Table A1: Study Characteristics						
First Author, Year; Design	**Country; No. of Centres; Funding**	**Comparison Arms**	**No. of Patients**	**No. of Surgeons**	**Length of Follow-up**	**Study Quality**
		Open radical retropubic prostatectomy	502		Mean 17.2 months ± 9.7	
Drouin, 2009;[79] Retrospective comparison	France; 1 centre; Funding NR	Da Vinci (3-arm system using transperitoneal technique)	71	3 surgeons for all	40.9 ± 5 months	B: good quality
		Open radical prostatectomy	83		57.7 ± 19 months	
		Laparoscopic radical prostatectomy	85		48.4 ± 11 months	
Durand, 2008;[41] Retrospective comparison	France; 1 centre; Funding NR	Da Vinci	34	2 surgeons for all	6 months	C: fair to good quality
		Retropubic total prostatectomy	29			
		Transperitoneal laparoscopic prostatectomy	23			
Farnham, 2006;[42] Prospective observational	US; 1 centre; Funding NR	Da Vinci	176	Single surgeon for both	NR	C: fair to good quality
		Radical retropubic prostatectomy	103			
Ficarra, 2009;[43] Prospective observational	Italy; 1 centre; No industry funding	Da Vinci (3-arm system using transperitoneal technique)	103	2	≥ 12 months	A: high quality
		Retropubic radical prostatectomy	105	4		
Fracalanza, 2008;[44] Prospective observational	Italy; 1 centre; No industry funding	Da Vinci (3-arm system using transperitoneal technique + antegrade prostatic dissection)	35	1	NR	C: fair to good quality
		Retropubic radical prostatectomy	26	3		

Table A1: Study Characteristics						
First Author, Year; Design	**Country; No. of Centres; Funding**	**Comparison Arms**	**No. of Patients**	**No. of Surgeons**	**Length of Follow-up**	**Study Quality**
Hakimi, 2009;[69] Retrospective comparison	US; 1 centre; Funding NR	Da Vinci (4-arm system)	75	Single surgeon for both	17 months	B: good quality
		Laparoscopic radical prostatectomy	75		48 months	
Ham, 2008;[45] Prospective observational	South Korea; 1 centre; Funding NR	Da Vinci (4-arm system)	223	Single surgeon for both	12 months	B: good quality
		Open retropubic prostatectomy	199			
Hohwü, 2009;[46] Retrospective comparison	Sweden; 2 centres; No industry funding	Da Vinci	127	NR	12 months	C: fair to good quality
		Open retropubic prostatectomy	147	NR		
Hu, 2006;[70] Retrospective comparison	US; 1 centre; Funding NR	Da Vinci (4-arm system with 2 assistant ports, using transperitoneal technique)	322	3 surgeons for both	NR	C: fair to good quality
		Laparoscopic radical prostatectomy	358			
Joseph, 2005;[71] Retrospective comparison	US; 1 centre; Funding NR	Da Vinci (5-port technique)	50	NR	≥ 3 months	C: fair to good quality
		Laparoscopic radical prostatectomy	50	NR		
Kordan, 2010;[47] Prospective observational	US; 1 centre; Funding NR	Da Vinci	830	2	NR	C: fair to good quality
		Open radical prostatectomy	414	3		

Table A1: Study Characteristics						
First Author, Year; Design	**Country; No. of Centres; Funding**	**Comparison Arms**	**No. of Patients**	**No. of Surgeons**	**Length of Follow-up**	**Study Quality**
Krambeck, 2009;[48] Prospective observational (robotic) compared with historical cohort	US; 1 centre; Funding NR	Da Vinci	294	3	Median 1.3 years	B: good quality
		Radical retropubic prostatectomy	588	17		
Laurila, 2009;[49] Retrospective comparison	US; 1 centre; No industry funding	Da Vinci (4-arm system using transperitoneal technique)	94	Single surgeon for all	NR	C: fair to good quality
		Open radical retropubic prostatectomy	98			
Lo, 2010;[50] Retrospective comparison	Hong Kong; 1 centre; Funding NR	Da Vinci (4-arm system)	20	NR	6 months	D: poor to fair quality
		Open radical prostatectomy	20	NR	42 months	
Madeb, 2007;[51] Retrospective comparison	US; 1 centre; Funding NR	Da Vinci	100	2 surgeons for both	NR	D: poor to fair quality
		Open radical prostatectomy	100			
Menon, 2002;[72] Prospective observational	US; 1 centre; Funding NR	Da Vinci	40	2	3.0 months	B: good quality
		Laparoscopic radical prostatectomy	40	NR	8.5 months	
Menon, 2002;[52] Prospective observational	US; 1 centre; Funding NR	Da Vinci	30	1	6 weeks	C: fair to good quality
		Open radical retropubic prostatectomy	30	8	NR	
Miller, 2007;[53] Prospective observational	US; 1 centre; Funding NR	Da Vinci (4-arm system with 2 assistant ports)	42	NR	6 weeks	C: fair to good quality
		Open radical prostatectomy	120	NR		

Table A1: Study Characteristics						
First Author, Year; Design	**Country; No. of Centres; Funding**	**Comparison Arms**	**No. of Patients**	**No. of Surgeons**	**Length of Follow-up**	**Study Quality**
Nadler, 2010;[54] Prospective observational (robotic) compared with historical cohort	US; 1 centre; Funding NR	Da Vinci (4-arm system with 5-port technique)	50	Single surgeon for both	Mean 27.1 months	C: fair to good quality
		Open radical retropubic prostatectomy	50		Mean 30.4 months	
Nelson, 2007;[55] Prospective observational	US; 1 centre; Funding NR	Da Vinci	629	NR	NR	C: fair to good quality
		Radical retropubic prostatectomy	374	NR		
O'Malley, 2006;[56] Prospective observational	Australia; 1 centre; Funding NR	Da Vinci (6-port set-up with 3 arms)	102	2 surgeons for both	NR	D: poor to fair quality
		Open radical retropubic prostatectomy	102			
Ou, 2009;[57] Retrospective comparison	Taiwan; 1 centre; Funding NR	Da Vinci (4-arm system for 1st 7 cases; 3-arm system for remainder)	30	Single surgeon for both	15 months	C: fair to good quality
		Radical retropubic prostatectomy	30			
Ploussard, 2009;[73] Prospective observational	France; 1 centre; No industry funding	Da Vinci	83	1	NR	C: fair to good quality
		Laparoscopic radical prostatectomy	205	2		
Prewitt, 2008;[58] Retrospective comparison	US; 1 centre; Funding NR	Da Vinci (4-arm system)	61	NR	NR	E: poor quality
		Open radical prostatectomy	100	NR		

Table A1: Study Characteristics						
First Author, Year; Design	**Country; No. of Centres; Funding**	**Comparison Arms**	**No. of Patients**	**No. of Surgeons**	**Length of Follow-up**	**Study Quality**
Rocco, 2009;[59] Prospective observational (robotic) compared with historical cohort	Italy; 1 centre; Funding NR	Da Vinci	120	3 surgeons for both	12 months	D: poor to fair quality
		Open retropubic prostatectomy	240			
Rozet, 2007[74] Retrospective comparison	France; 1 centre; Funding NR	Da Vinci	133	4 surgeons for both	NR	C: fair to good quality
		Laparoscopic radical prostatectomy	133			
Schroeck, 2008;[60] Retrospective comparison	US; 1 centre; No industry funding	Da Vinci (3-arm system using the Vattikuti Institute technique)	362	4	1.09 years	C: fair to good quality
		Radical retropubic prostatectomy	435	6	1.37 years	
Smith, 2007;[61] Retrospective comparison	US; 1 centre; Funding NR	Da Vinci (5-port technique)	200	2 surgeons for both	NR	C: fair to good quality
		Open retropubic radical prostatectomy	200			
Srinualnad, 2008;[75] Prospective observational (robotic) compared with historical cohort	Bangkok; 1 centre; Funding NR	Da Vinci (6 trocar technique)	34	Single surgeon for both	1 month	D: poor to fair quality
		Laparoscopic radical prostatectomy	34			
Tewari, 2003;[62] Prospective observational	US; 1 centre; Funding NR	Da Vinci (using Vattikuti Institute technique)	200	1	236 days	C: fair to good quality
		Radical retropubic prostatectomy	100	8	556 days (P=<0.05)	

Table A1: Study Characteristics						
First Author, Year; Design	**Country; No. of Centres; Funding**	**Comparison Arms**	**No. of Patients**	**No. of Surgeons**	**Length of Follow-up**	**Study Quality**
Trabulsi, 2008;[76] Retrospective comparison	US; 1 centre; Funding NR	Da Vinci	50	NR	NR	C: fair to good quality
		Transperitoneal laparoscopic radical prostatectomy	190	NR		
Trabulsi, 2010;[77] Retrospective comparison	US; 1 centre; Funding NR	Da Vinci (using transperitoneal technique)	205	Single surgeon for both	24 months	C: fair to good quality
		Laparoscopic radical prostatectomy	45			
Truesdale, 2010;[63] Retrospective comparison	US; 1 centre; Funding NR	Da Vinci	99	1	NR	D: poor to fair quality
		Open radical prostatectomy	217	4		
Webster, 2005;[64] Prospective observational	US; 1 centre; Funding NR	Da Vinci	159	NR	NR	C: fair to good quality
		Retropubic radical prostatectomy	154	NR		
White, 2009;[65] Retrospective comparison	US; 1 centre; Funding NR	Da Vinci (using Vattikuti Institute technique)	50	Single surgeon for both	NR	C: fair to good quality
		Radical retropubic prostatectomy	50			
Williams, 2010;[66] Retrospective comparison	US; 1 centre; Funding NR	Da Vinci	604	1	NR	D: poor to fair quality
		Open radical retropubic prostatectomy	346	1		
Wood, 2007;[67] Prospective observational	US; 1 centre; Funding NR	Da Vinci	165	NR	6 weeks	C: fair to good quality
		Conventional prostatectomy	152	NR		

Table A1: Study Characteristics						
First Author, Year; Design	**Country; No. of Centres; Funding**	**Comparison Arms**	**No. of Patients**	**No. of Surgeons**	**Length of Follow-up**	**Study Quality**
Zorn, 2009;[68] Prospective observational (robotic) compared with historical cohort	US; 1 centre; Funding NR	Da Vinci	296	3	NR	C: fair to good quality
		Open radical prostatectomy	471	1		
Hysterectomy						
Bell, 2008;[102] Retrospective comparison	US; 1 centre; Funding NR	Da Vinci	40	Single surgeon for all	NR	C: fair to good quality
		Open hysterectomy	40			
		Laparoscopic hysterectomy	30			
Boggess, 2008;[103] Prospective observational (robotic) compared with historical cohort	US; 1 centre: Funding NR	Da Vinci (using a 5-trocar transperitoneal approach)	103	NR	NR	C: fair to good quality
		Open hysterectomy	138	NR		
		Laparoscopic hysterectomy	81	NR		
Boggess, 2008;[80] Prospective observational (robotic) compared with historical cohort	US; 1 centre; Funding NR	Da Vinci (5-trocar transperitoneal technique, type III radical hysterectomy with pelvic lymph node dissection)	51	Single surgeon for both	NR	D: poor to fair quality
		Open radical hysterectomy	49			
Cantrell, 2010;[81] Retrospective comparison	US; 1 centre; Funding NR	Da Vinci	64	Single surgeon for 94%	Up to 36 months	C: fair to good quality
		Open Piver type III radical hysterectomy	63	6	36 months	

Table A1: Study Characteristics						
First Author, Year; Design	**Country; No. of Centres; Funding**	**Comparison Arms**	**No. of Patients**	**No. of Surgeons**	**Length of Follow-up**	**Study Quality**
Cardenas-Goicoechea, 2010[94] Retrospective comparison	US; 1 centre; Funding NR	Da Vinci	102	Single surgeon for both	NR	B: good quality
		Laparoscopic hysterectomy	173			
DeNardis, 2008;[82] Retrospective comparison	US; 1 centre; No industry funding	Da Vinci (hysterectomy with pelvic lymphadenectomy)	56	NR	NR	C: fair to good quality
		Open total hysterectomy with pelvic lymphadenectomy	106	NR		
Estape, 2009;[104] Prospective observational (robotic) compared with historical cohort	US; 1 centre; Funding NR	Da Vinci (5-trocar transperitoneal technique, radical hysterectomy)	32	NR	284.2 ± 152.1 days	B: good quality
		Open hysterectomy	14	NR	1382.4 ± 592.7 days	
		Laparoscopic hysterectomy	17	NR	941.6 ± 273.9 days	
Feuer, 2010;[83] Prospective observational (robotic) compared with historical cohort	US; 1 centre; Funding NR, 2 individuals involved in writing report were affiliated with Intuitive Surgical	Da Vinci (3-arm system; 5-trocar technique) radical hysterectomy using a modified unilateral Wertheim procedure	32	Single surgeon for both	NR	B: good quality
		Open radical hysterectomy using a modified unilateral Wertheim procedure	20			
Gehrig, 2008;[95] Retrospective comparison	US; 1 centre; Funding NR	Da Vinci	49	NR	NR	D: poor to fair quality
		Laparoscopic hysterectomy	32	NR		

Table A1: Study Characteristics						
First Author, Year; Design	**Country; No. of Centres; Funding**	**Comparison Arms**	**No. of Patients**	**No. of Surgeons**	**Length of Follow-up**	**Study Quality**
Geisler, 2010[84] Retrospective comparison	US; 1 centre; Public funding	Da Vinci (4-arm system; type III radical hysterectomy and bilateral pelvic lymphadenectomy)	30	NR	90 days	C: fair to good quality
		Open type III radical hysterectomy	30	NR		
Gocmen, 2010;[85] Prospective observational	Turkey; 1 centre; Funding NR	Da Vinci (5-trocar transperitoneal approach; hysterectomy combined with pelvic lymph node dissection, or pelvic-paraaortic lymph node dissection)	10	Single surgeon for both	At least 12 months	C: fair to good quality
		Laparotomy; hysterectomy combined with pelvic lymph node dissection, or pelvic-paraaortic lymph node dissection	12			
Halliday, 2010[86] Prospective observational (robotic) compared with historical cohort	Canada; 1 centre; Funding from cancer societies	Da Vinci S (5-port technique; radical hysterectomy)	16	2 surgeons for both	NR	B: good quality
		Open radical hysterectomy	24			
Holtz, 2010;[96] Retrospective comparison	US; 1 centre; Funding NR but first author is a proctor for Intuitive Surgical	Da Vinci hysterectomy, bilateral salpingo-oophorectomy, pelvic and peri-aortic lymph node resection, and cystoscopy	13	Single surgeon for both	NR	C: fair to good quality
		Laparoscopic hysterectomy, bilateral salpingo-oophorectomy, pelvic and peri-aortic lymph node resection, and cystoscopy	20			

Table A1: Study Characteristics						
First Author, Year; Design	**Country; No. of Centres; Funding**	**Comparison Arms**	**No. of Patients**	**No. of Surgeons**	**Length of Follow-up**	**Study Quality**
Jung, 2010;[105] Prospective observational	Korea; 1 centre; Gov't grant	Da Vinci-S (using 3 arms)	28	2 surgeons for all	NR	C: fair to good quality
		Laparoscopic staging for endometrial cancer	25			
		Open surgery staging for endometrial cancer	56			
Ko, 2008;[87] Retrospective comparison	US; 1 centre; Funding NR	Da Vinci (5 port site placements; type III radical hysterectomy)	16	2	NR	C: fair to good quality
		Open hysterectomy	32	6		
Lowe, 2010;[88] Prospective observational	US; 1 centre; Funding NR	Da Vinci	7	1	NR	C: fair to good quality
		Open radical hysterectomy	7	4		
Maggioni, 2009;[89] Prospective observational (robotic) compared with historical cohort	Italy; 1 centre; No industry funding	Da Vinci	40	NR	NR	B: good quality
		Open hysterectomy (radical and modified)	40	NR		
Nevadunsky, 2010;[90] Retrospective comparison	US; 1 centre; Funding NR	Da Vinci S (5 trocar placements)	66	2 surgeons for both	NR	D: poor to fair quality
		Open total hysterectomy	43			
Nezhat, 2009;[97] Retrospective comparison	US; 1 centre; Funding NR	Da Vinci	26	NR	NR	D: poor to fair quality
		Laparoscopic hysterectomy	50	NR		

Table A1: Study Characteristics						
First Author, Year; Design	**Country; No. of Centres; Funding**	**Comparison Arms**	**No. of Patients**	**No. of Surgeons**	**Length of Follow-up**	**Study Quality**
Payne, 2008;[98] Retrospective comparison	US; 2 centres; Funding NR	Da Vinci (4 trocar placements)	100	2	NR	C: fair to good quality
		Laparoscopic hysterectomy	100	2		
Schreuder, 2010;[91] Retrospective comparison	The Netherlands; 1 centre; No industry funding but lead author is a proctor for Intuitive Surgical	Da Vinci (4-arm system)	14	Single surgical team for both	NR	C: fair to good quality
		Open radical hysterectomy	14			
Seamon, 2009;[99] Prospective observational (robotic) compared with historical cohort	US; 1 centre; Funding NR	Da Vinci	105	2	NR	C: fair to good quality
		Laparoscopic hysterectomy and lymphadenectomy	76	2		
Seamon, 2009;[92] Prospective observational	US; 2 centres; Funding NR	Da Vinci (4-arm system)	109	2	NR	C: fair to good quality
		Open hysterectomy and lymphadenectomy	191	2		
Sert, 2007;[100] Prospective observational (robotic) compared with historical cohort	Norway; 1 centre; Funding NR	Da Vinci (3-arm system with 5 trocars)	7	Single surgeon for all	Median 14 days (range 13-18)	C: fair to good quality
		Laparoscopic total radical hysterectomy	8		Median 25 days (range 20-36)	

Table A1: Study Characteristics						
First Author, Year; Design	**Country; No. of Centres; Funding**	**Comparison Arms**	**No. of Patients**	**No. of Surgeons**	**Length of Follow-up**	**Study Quality**
Shashoua, 2009;[101] Retrospective comparison	US; 2 centres; Funding NR	Da Vinci (5 port technique)	24	Single surgeon for all	NR	C: fair to good quality
		Laparoscopic total hysterectomy	44			
Veljovich, 2008;[93] Prospective observational (robotic) compared with historical cohort	US; 1 centre; Funding NR	Da Vinci	25	4	NR	D: poor to fair quality
		Open hysterectomy	131	NR		
Nephrectomy						
Aron, 2008;[106] Retrospective comparison	US; 1 centre; Funding NR	Da Vinci (7-port placement technique for right-sided procedures; 6-ports for left-side)	12	NR	7.4 ± 5.2 months	C: fair to good quality
		Laparoscopic partial nephrectomy	12	NR	8.5 ± 5.6 months	
Benway, 2009;[107] Retrospective comparison	US; 3 centres; Funding NR	Da Vinci (3 arms used for most procedures, with 4 arms used for challenging tumour configurations and excess perirenal fat)	129	3	Up to 1 year	C: fair to good quality
		Laparoscopic partial nephrectomy	118	3	Up to 4 years	

Table A1: Study Characteristics						
First Author, Year; Design	**Country; No. of Centres; Funding**	**Comparison Arms**	**No. of Patients**	**No. of Surgeons**	**Length of Follow-up**	**Study Quality**
Deane, 2008;[108] Retrospective comparison	US; 1 centre; Funding NR	Da Vinci (5-port placement technique)	11	1	16 months (range 4-37)	C: fair to good quality
		Laparoscopic partial/wedge nephrectomy	11	2	4.5 months (1-8)	
DeLong, 2010;[109] Retrospective comparison	US; 1 centre; Funding NR	Da Vinci transperitoneal partial nephrectomy (4-arm system; 7 trocars for right-sided procedures; 6 trocars for left-side)	13	Single surgeon for both	6 months	C: fair to good quality
		Laparoscopic transperitoneal partial nephrectomy	15			
Haber, 2010;[110] Retrospective comparison	US; 1 centre; Funding NR; 1 author is a speaker for Intuitive Surgical	Da Vinci (3-arm system)	75	Single surgeon for both	NR	C: fair to good quality
		Laparoscopic partial nephrectomy	75			
Hemal, 2009;[111] Prospective observational	Country NR 1 centre; Funding NR	Da Vinci-S (6-port technique)	15	Single surgeon for all	8.3 months (range 1-12)	B: good quality
		Laparoscopic radical nephrectomy	15		9.1 months (2-12)	

Table A1: Study Characteristics						
First Author, Year; Design	**Country; No. of Centres; Funding**	**Comparison Arms**	**No. of Patients**	**No. of Surgeons**	**Length of Follow-up**	**Study Quality**
Jeong, 2009;[112] Prospective observational	Korea; 1 centre; No industry funding	Da Vinci (3 arms used; 4-port technique)	31	Single surgeon for all	NR	D: poor to fair quality
		Laparoscopic partial nephrectomy	15			
Kural, 2009;[113] Prospective observational	Turkey; 1 centre; No industry funding	Da Vinci (3 arms used in 8 cases; 4 arms used in 3 cases; 5-port technique)	11	NR	7.54 months (range 3-14)	C: fair to good quality
		Laparoscopic partial nephrectomy (+ 1 hand-assisted)	20	NR	38 months (19-66) (P<0.0001)	
Nazemi, 2006;[115] Prospective observational	US; 1 centre; Funding NR	Da Vinci	6	Single surgeon for all	Median 4 months (range1-10)	C: fair to good quality
		Open radical nephrectomy	18		Median 15 months (range1-31)	
		Laparoscopic nephrectomy with hand assistance	21		Median 5 months (range1-25)	
		Laparoscopic nephrectomy	12		7 (1-21) (P=0.07)	
Wang, 2009;[114] Retrospective comparison	US; 1 centre; Funding NR	Da Vinci-S (4-arm system)	40	Single surgeon for all	NR	C: fair to good quality
		Laparoscopic partial nephrectomy	62			

Table A1: Study Characteristics						
First Author, Year; Design	**Country; No. of Centres; Funding**	**Comparison Arms**	**No. of Patients**	**No. of Surgeons**	**Length of Follow-up**	**Study Quality**
Cardiac Surgeries						
Ak, 2007;[116] Retrospective comparison	Germany; 1 centre; Funding NR	Da Vinci totally endoscopic atrial septal repair	24	All operations were performed by 2 surgeons	30 ± 24.3 months (range 3-105) for all	C: fair to good quality
		Partial lower sternotomy	16			
		Right anterior small thoracotomy with transthoracic clamping	20			
		Right anterior small thoracotomy with endoaortic balloon clamping	4			
Folliguet, 2006;[118] Prospective observational (robotic) compared with historical cohort	France; 1 centre; Funding NR	Da Vinci	25	Single surgeon for all	24 months	C: fair to good quality
		Sternotomy mitral valve repair	25			
Kam, 2010;[119] Retrospective comparison	Australia; 1 health network (no. of centres NR); Funding NR	Da Vinci (mitral valve repair)	104	1	NR	C: fair to good quality
		Conventional mitral valve repair	40	11		
Mihaljevic, 2011;[120] Retrospective comparison	US; 1 centre: No industry funding	Da Vinci (mitral valve repair)	261	NR	≥ 30 days	C: fair to good quality
		Complete sternotomy	114	NR		

Table A1: Study Characteristics						
First Author, Year; Design	**Country; No. of Centres; Funding**	**Comparison Arms**	**No. of Patients**	**No. of Surgeons**	**Length of Follow-up**	**Study Quality**
Morgan, 2004;[117] Prospective observational (robotic) compared with historical cohort	US; 1 centre; Funding NR	Da Vinci (atrial septal defect repair)	16	NR	30 days	C: fair to good quality
		Sternotomy	17	NR	NR	
		Mini-thoracotomy	17	NR	NR	
Poston, 2008;[123] Prospective observational	US; 1 centre; No industry funding	Da Vinci (mini CABG)	100	NR	1 year	A: high quality
		Off-pump coronary artery bypass grafting	100	NR		
Tabata, 2006;[121] Retrospective comparison	US; 1 centre; Funding NR	Da Vinci (mitral valve repair)	5	NR	45 ± 10 months	D: poor to fair quality
		Minimally invasive mitral valve repair with direct vision for MR	123	NR	54 ± 32 months	
Woo, 2006;[122] Retrospective comparison	US; 1 centre; Funding NR	Da Vinci (mitral valve reconstruction)	25	Single surgeon for all	NR	C: fair to good quality
		Sternotomy	39			

NR=not reported.

Appendix 7: Additional Study and Patient Characteristics

Table A2: Prostatectomy; Additional Characteristics of Included Studies					
Study	**Surgeon Expertise and Learning Curve**	**Outcome Definitions (operative time, continence, sexual function, criteria for transfusion)**	**Patient Character-istic Difference s for Each Arm**	**Patient Assignment**	**Reporting of Complications**
Ahlering, 2004[29]	Single surgeon; 18 years of experience; compared surgeries after 45 robotic cases, when learning curve was believed to have sufficiently matured (no detail on parameters used to define maturity)	**Oper time** = not defined; **Continence** = 0 pads; **Sexual function** = NR; **Criteria for transfusion** = not defined	No obvious differences	Retrospective. Appears to be all patients of a single surgeon within a specified time period; reason for assignment to type of surgery NR	**Postop**: pulmonary embolism; urine leak; prolonged ileus; delayed bleeding; DVT **Intraop**: encroachment on orifice requiring ureteral stent placement
Ball, 2006[78]	Open surgery by 3 fellowship-trained oncologic surgeons; laparoscopic surgery by 2 surgeons with advanced laparoscopic fellowship training and mentoring; Robotic surgery by 2 surgeons following completion of robotic training and proctoring. No consideration was given to a possible learning curve	**Oper time** = NR; **Continence** = not defined; **Sexual function** = not defined; **Criteria for transfusion** = not defined	Robotic surgery group significantly lower PSA at pre-op; clinical stage significantly different; type of nerve-sparing surgery differed significantly	Prospective. All patients in a certain time period were included if they consented. Not specified how patients were allocated to each of the 3 arms	NR
Barocas, 2010[30]	Surgeon experience NR; 2 surgeons performed only robotic surgery, 2 only open surgery, 2 performed both procedures. No consideration was given to a possible learning curve	None of these outcomes were reported	Open surgery group had higher risk clinical characteristic s (higher median PSA, higher proportion of clinically palpable disease, higher biopsy	Retrospective. Included all patients in a certain time period. Procedure selection was at the discretion of the surgeon and patient	NR

Table A2: Prostatectomy; Additional Characteristics of Included Studies					
Study	**Surgeon Expertise and Learning Curve**	**Outcome Definitions (operative time, continence, sexual function, criteria for transfusion)**	**Patient Character-istic Difference s for Each Arm**	**Patient Assignment**	**Reporting of Complications**
			Gleason score)		
Boris, 2007[31]	Single surgeon with extensive experience in open retropubic and open perineal surgery; previous training with 50 patients in robotic surgery. No other consideration was given to a possible learning curve	**Oper time =** skin incision to skin or port closure; **Continence =** zero pads; **Sexual function** = NR; **Criteria for transfusion =** NR	Reported to be comparable	Consecutive patients chosen for study; type of surgery decided by patient following consultation with surgeon	**Periop:** atrial fibrillation, colostomy, urinary retention, fever, oxygen desaturation, persistent hypotension, rectal injuries, vesicocutaneous fistula
Breyer, 2010[32]	NR	**Oper time** = NR; **Continence =** NR; **Sexual function** = NR; **Criteria for transfusion** = not defined	Significantly more men with cT2 disease in open prostatectom y group	All patients in a specific time period requiring radical prostatectomy ; reason for assignment to either surgery NR	**Periop:** bladder neck contracture
Burgess, 2006[33]	Surgeon expertise NR but appears to have been minimal initially. All robotic surgery cases were included in outcomes, however the last 20 cases (of 78 total) were considered to be post-learning curve, based on operative charges (largely a result of decrease in operative time)	**Oper time** = not defined; **Others** = NR	Reported to be similar	Retrospective. Consecutive prostatectomi es; not specified how patients were allocated to the 3 arms	NR
Carlsson, 2010[34]	Surgeons had no experience in robotic surgery at start of study. Outcome data include those during the initial learning curve, which was not defined. Surgeons operating with the open technique were very experienced	**Oper time =** NR; **Continence =** not defined; **Sexual function** = NR; **Criteria for transfusion =** NR	Open group had significantly higher preoperative PSA levels and significantly more patients with	No formal selection criteria; choice of method depended on the treating physician	**Intraop:** rectal injury, ureteral injury, femoral nerve injury, obturator nerve injury **Postop:** death, rectal injury, pulmonary embolism, pneumonia, infected lymphocele, wound infections, anastomotic leakage,

Table A2: Prostatectomy; Additional Characteristics of Included Studies					
Study	**Surgeon Expertise and Learning Curve**	**Outcome Definitions (operative time, continence, sexual function, criteria for transfusion)**	**Patient Character-istic Differences for Each Arm**	**Patient Assignment**	**Reporting of Complications**
			cT3 Gleason score		bladder neck contracture
Chan, 2008[35]	All surgeons had previous experience, but no details provided on experience; learning curve was not a consideration	**Oper time** = not defined; **Continence =** NR; **Sexual function** = NR; **Criteria for transfusion** = NR	Open surgery group had higher mean PSA	Consecutive patients chosen for inclusion; surgical approach was based on patient preference following consultation with surgeon	NR
Chino, 2009[36]	NR	None of these outcomes were reported	RALP had lower pre-treatment PSA, lower Gleason score, and lower clinical T stage	Retrospective study of all patients in a certain time frame; reason for assignment to type of surgery NR	NR
Coronato, 2009[37]	NR	None of these outcomes were reported	No significant differences between the groups for patient characteristics except PSA, which was higher in the open retropubic surgery group than the others	Retrospective study of all patients in a certain time frame; reason for assignment to type of surgery NR	NR

Table A2: Prostatectomy; Additional Characteristics of Included Studies					
Study	**Surgeon Expertise and Learning Curve**	**Outcome Definitions (operative time, continence, sexual function, criteria for transfusion)**	**Patient Character-istic Difference s for Each Arm**	**Patient Assignment**	**Reporting of Complications**
D'Alonzo, 2009[38]	2 surgeons performed robotic surgery (77% of procedures performed by one, who had prior experience with laparoscopic surgery but not robotic; the 2nd surgeon had no prior laparoscopic experience). Outcome data include those during the initial learning curve, which was not defined	**Oper time**: **Surgical time =** 1st incision to end of surgery, **Anesthesia time** = patient entering OR to patient delivery to PACU; **Continence** = NR; **Sexual function =** NR; **Criteria for transfusion** = not defined	No significant differences	Retrospective study of all patients in a certain time frame; reason for assignment to type of surgery NR	**Postop:** pulmonary embolism; anastomotic leak with pancolitis
Di Pierro, 2011[39]	Surgeon for robotics had 6 months experience with laparoscopic and robotic surgery; surgeons for open surgery each had caseloads of >100 procedures; learning curve for robotic procedure not defined	**Oper time =** not defined; **Continence =** no leakage; **Sexual function =** erection that allowed sexual intercourse including use of PDE5-Is following surgery; **Criteria for transfusion =** not defined	Characteristics comparable for both groups	Last 75 robotic surgery patients and first 75 open surgery patients; reason for assignment to each surgery NR	**Periop:** pressure skin redness, lymphocele, pressure skin ulcer, suspected malignant hyperthermia, epididymitis, venous thrombosis, postop Addison crisis, femoral nerve deficit, bladder tamponade, retention after catheter removal, anastomosis stricture, ureteral injury, port hernia, paralytic ileus, perineal nerve deficit, utereral ostium lesion, rectal injury, wound dehiscence, multiple pelvic abscess
Doumerc, 2010[40]	Little or no prior experience with robotic surgery; learning curve was calculated based on positive margin rates (using the Joinpoint Regression Program) to be 140 cases for pT2 positive margin rates, and 170 cases for pT3	**Oper time =** console time for robotic surgery; **Continence =** No pads, or just one safety pad to protect against occasional leak of a few drops of urine; **Sexual function**	Patient demographics similar in both arms except significantly higher numbers of high-stage and high-grade	Surgeon's preference, based on patient and tumour	**Periop:** bleeding requiring surgery, local cellulitis requiring surgery, small bowel injury requiring surgery, death due to CVA, CVA with minor sensory deficits, pulmonary embolism, pelvic hematoma requiring surgery

Table A2: Prostatectomy; Additional Characteristics of Included Studies					
Study	**Surgeon Expertise and Learning Curve**	**Outcome Definitions (operative time, continence, sexual function, criteria for transfusion)**	**Patient Characteristic Differences for Each Arm**	**Patient Assignment**	**Reporting of Complications**
		= NR; **Criteria for transfusion =** NR	tumours in open surgery group		
Drouin, 2009[79]	3 "seasoned" surgeons, including an experienced robotic surgery operator; no specific time given for learning curve	**Oper time** = not defined; **Continence** = NR; **Sexual function** = NR; **Criteria for transfusion** = not defined	No significant differences	Retrospective study of all patients in a certain time frame. Type of surgery was at physician's discretion.	**Postop:** urinary retention; postop bleeding; urinary infection; anastomotic leakage; lymphocele **Intraop:** rectal injury
Durand, 2008[41]	2 experienced surgeons, but cases of robotic surgery included learning curve cases; no definition of learning curve provided	**Oper time** = not defined; **Continence =** not defined; **Sexual function** = NR; **Criteria for transfusion =** not defined	No significant differences	Retrospective study; reason for assignment to type of surgery NR	**Post op**: orchitis, anastomose leak, lymphocele
Farnham, 2006[42]	Surgeon expertise NR; Single surgeon; no definition of learning curve	**Oper time** = NR; **Continence** = NR; **Sexual function** = NR; **Criteria for transfusion** = not defined	Radical retropubic surgery group had higher PSA; other characteristics similar (including Gleason score at biopsy and pathological findings)	Prospective. Included all patients of single surgeon during a certain time period. Type of surgery was patient's choice after discussion of pros and cons	Only blood loss and hematocrit were reported
Ficarra, 2009[43]	2 surgeons performed robotic surgery and had completed at least 50 robotic surgeries each before study; radical retropubic surgery by 4 surgeons who had completed at least 400 surgeries each before study; suggest that learning curve is	**Oper time** = not defined; **Continence** = dry safety pad within 1st 24 hrs; **Continence at 12-month follow-up** = no leaks, or leaks less than 1/wk; **Sexual function**	All characteristics comparable except age (significantly younger robotic surgery group)	Prospective. Consecutive patients within a certain time period. Type of surgery based on joint decision by patients and physicians	**Postop:** postop bleeding, paralytic ileus, cardiovascular complications, wound dehiscence, overall **Intraop:** colon lesion, rectal lesion

Table A2: Prostatectomy; Additional Characteristics of Included Studies					
Study	**Surgeon Expertise and Learning Curve**	**Outcome Definitions (operative time, continence, sexual function, criteria for transfusion)**	**Patient Character-istic Difference s for Each Arm**	**Patient Assignment**	**Reporting of Complications**
	complete after approximately 20 cases for surgeons with no previous laparoscopic experience	= patients defined as potent with IIEF-5 score of >17; **Criteria for transfusion** = not defined			
Fracalanza, 2008[44]	1 surgeon performed robotic surgery with previous experience >50 cases; 3 surgeons for retropubic surgery group, each with previous experience >200 cases; no definition of learning curve	**Oper time** = not defined; **Duration of anesthesia** also reported; **Continence** = NR; **Sexual function** = NR; **Criteria for transfusion** = not defined	All characteristic s comparable except age (significantly younger robotic surgery group)	Prospective. Consecutive patients within a certain time period. Type of surgery was joint decision by patients and physicians	**Postop:** fever; significant post op bleed requiring transfusion
Hakimi, 2009[69]	Single surgeon (laparoscopically naïve): robotic surgery group were 1st 75 patients; laparoscopic surgery group were last 80 of >300 patients; no definition of learning curve	**Oper time** = skin to skin; **Continence** = no pad use and no leakage; **Sexual function** = potent if able to maintain an erection sufficient for intercourse with or without use of oral phosphodiesteras e-5 inhibitors; **Transfusions** = NR	Comparable	Retrospective study of patients in a certain time frame; reason for assignment to type of surgery NR	**Classified in study as periop and postop together:** pulmonary embolus, DVT, urinary tract sepsis, anastomotic stricture, hematuria, bladder neck contracture, lymphocele, postop bleeding, urinary retention, ileus, prolonged Jackson-Pratt drainage
Ham, 2008[45]	Single surgeon; previously performed 89 open surgeries, but no previous laparoscopic experience; learning curve was considered to be the first 35 cases (chosen arbitrarily)	**Oper time =** NR; **Continence =** no pad use and no leakage; **Sexual function =** potent if able to maintain an	PSA significantly lower in robotic surgery group	All patients of a single surgeon; type of surgery chosen by patients following thorough	**Periop:** rectal injury, infected hematoma, retention, anastomotic leakage, lymphocele, ileus

Table A2: Prostatectomy; Additional Characteristics of Included Studies					
Study	**Surgeon Expertise and Learning Curve**	**Outcome Definitions (operative time, continence, sexual function, criteria for transfusion)**	**Patient Character-istic Differences for Each Arm**	**Patient Assignment**	**Reporting of Complications**
		erection sufficient for intercourse with or without use of oral phosphodiesterase-5 inhibitors; **Transfusions** = NR		discussion with surgeon	
Hohwü, 2009[46]	NR	NR	PSA higher in open surgery group, more obesity in open surgery group (significance NR)	Retrospective study of patients in a certain time frame; reason for assignment to type of surgery NR	NR; only sick days and return-to-work info reported
Hu, 2006[70]	Surgeon expertise NR, but does include initial cases early in the laparoscopic and robotic learning curves; learning curve not defined	**Oper time** = interim between Veress needle insertion and skin closure, including time for robot preparation and docking for RAP; **Others** = NR	Significance of differences NR; Gleason scores higher and greater % of high risk patients for LRP	Retrospective study of patients in a certain time frame; reason for assignment to type of surgery NR	**Postop:** urine leakage; urine retention; bladder contracture; clot retention; rectourethral fistulas; ileus; postop bleeding; cellulitis; orchitis; *C.difficile* enterocolitis; pneumonia; bacterial peritonitis; lymphocele; acute tubular necrosis; DVT; intra-abdominal drain retraction. **Intraop:** ureteral injury; rectal injuries; hemocolonic injury; obturator nerve injury; ulnar nerve neuropraxia; median nerve neuropraxia; lumbosacral plexus neuropraxia; epigastric artery injury; robot malfunction

Table A2: Prostatectomy; Additional Characteristics of Included Studies					
Study	**Surgeon Expertise and Learning Curve**	**Outcome Definitions (operative time, continence, sexual function, criteria for transfusion)**	**Patient Character-istic Difference s for Each Arm**	**Patient Assignment**	**Reporting of Complications**
Joseph, 2005[71]	Study included the last 50 patients of 78 laparoscopic and 200 robotic in an attempt to limit bias due to the learning curve; learning curve not defined	**Oper time** = total time including anesthesia time, pre-docking/after docking times; **Continence** = totally dry and using no pads, and leakage verified using Valsalva manoeuvre or coughing; **Sexual function:** IIEF-5 scores for erection recorded at 3 months; **Transfusions = 0**	Similar demographic s	Retrospective study of patients in a certain time frame; reason for assignment to type of surgery NR	**Postop:** Bladder neck contractures, urinary leaks
Kordan, 2010[47]	Surgeon expertise NR, but centre had high volumes of both surgery types; learning curve not defined	**Oper time =** NR; **Continence =** NR; **Sexual function =** NR; **Criteria for transfusion =** hematocrit of <28% was considered an indication for transfusion	PSA significantly higher in open prostatectom y group; Gleason score significantly lower in open prostatectom y group	Consecutive patients; type of surgery decided by patient following consultation with surgeon	**NR**

Table A2: Prostatectomy; Additional Characteristics of Included Studies					
Study	**Surgeon Expertise and Learning Curve**	**Outcome Definitions (operative time, continence, sexual function, criteria for transfusion)**	**Patient Character-istic Difference s for Each Arm**	**Patient Assignment**	**Reporting of Complications**
Krambeck, 2009[48]	Surgeon expertise NR; initial 294 cases of robotic surgery matched with retropubic surgery during same time; most robotic surgeries done by 1 surgeon; retropubic surgeries by 17 surgeons; Operative times given for procedures performed early, middle, and late in the program; estimate learning curve to be complete at 10 to 20 cases but basis for this is not given	**Oper time** = time of anesthesia induction to laryngeal extubation, included docking of robotic system but not the set-up; **Continence** = no leakage, or security pad only; **Sexual function** = potency defined as erections satisfactory for intercourse with or without PDE-5 inhibitors; **Criteria for transfusion** = no defined protocol therefore transfusion rates reflect individual surgeons' decisions and not solely surgical technique (according to authors)	Similar demographic s	Retrospective. Consecutive robotic surgery patients within a certain time period matched with retropubic surgery patients. Patient decision for procedure	**Postop:** urinary retention; UTI; DVT; drug reaction; ileus ; lymphocele ; lymphedema; pulmonary embolism; respiratory failure; stroke; bladder neck contracture. **Intraop:** hemorrhage/hematoma; stricture; uretic obstruction; incisional hernia
Laurila, 2009[49]	Single surgeon; 1st 20 cases excluded to minimize learning curve effect (based on operative time below 180 minutes for robotic group)	None of these outcomes were reported	Similar demographic s except significantly higher PSA in open surgery group (risk-stratified analysis by authors to correct for this)	Retrospective. Consecutive patients within a certain time period; reason for assignment to type of surgery NR	NR

Table A2: Prostatectomy; Additional Characteristics of Included Studies					
Study	**Surgeon Expertise and Learning Curve**	**Outcome Definitions (operative time, continence, sexual function, criteria for transfusion)**	**Patient Character-istic Difference s for Each Arm**	**Patient Assignment**	**Reporting of Complications**
Lo, 2010[50]	Surgeons performing open surgery had little experience; surgeons for robotic surgeries had prior experience; definition of learning curve not provided	**Oper time** = not defined; **Continence** = 0 pads/day; **Sexual function** = NR; **Criteria for transfusion** = not defined	No significant differences	Retrospective. Consecutive patients within a certain time period prospectively for robotic surgery compared with historical cohort for open surgery	NR
Madeb, 2007[51]	Surgeons very experienced with open surgery, but no experience in robotic surgery; learning curve surgeries were included but learning curve was not defined	None of these outcomes were reported	No significant differences	Last 50 open surgery patients compared with first 50 robotic surgery patients for each surgeon; reason for assignment to type of surgery NR	NR
Menon, 2002[72]	Surgeons experienced in laparoscopic procedure, but robotic group included the learning curve; longitudinal analysis was used to calculate the learning curve for robotic surgery to be about 18 cases (based on operative times)	**Oper time** = skin-to-skin; **Continence** = no pads; **Sexual function** = not defined; **Criteria for transfusion** = not defined	No significant differences	Prospective. Consecutive patients within a certain time period. NR how decision for which procedure was made, except that patients >250 lb. recommended to undergo laparoscopic surgery	**Postop:** paralytic ileus, port hernia, entrapment of ureter in vesicourethral anastomotic stitch, pelvic hematoma

Table A2: Prostatectomy; Additional Characteristics of Included Studies					
Study	**Surgeon Expertise and Learning Curve**	**Outcome Definitions (operative time, continence, sexual function, criteria for transfusion)**	**Patient Character-istic Difference s for Each Arm**	**Patient Assignment**	**Reporting of Complications**
Menon, 2002[52]	Surgeon for robotic surgery had mentoring; 8 surgeons for open surgery had individual experiences of 100 to 1,000 cases (total for 8 surgeons > 2,500 cases); classified the first 20 cases of robotic surgery as early, based on significantly lower set-up times, operative times, blood loss, and catheterization duration of the following cases	**Oper time** = incision or dissection to closure; set up = time from start of pneumoperitoneu m to start of dissection (incl. preparing robot, port placement, and docking the arms); **Continence** = NR; **Sexual function** = NR; **Criteria for transfusion** = not defined	No statistically significant differences except for PSA, which was significantly greater in the robotic surgery arm	NR	**Postop:** urinary retention, ileus, exaggeration of arthritis, wound dehiscence **Intraop:** rectal injuries, bleeding >1,000 mL
Miller, 2007[53]	NR	None of these outcomes were reported	No statistically significant differences	Retrospective study of patients in a certain time frame; reason for assignment to type of surgery NR	Only QoL scores reported
Nadler, 2010[54]	Surgeon experienced in radical and laparoscopic surgery, but not robotic surgery; learning curve determined to be first ten cases (based on operative times)	**Oper time** = NR; **Continence** = No pads, or 1 precautionary pad per day; **Sexual function** = Potency defined as SHIM >17 (Sexual Health Inventory for Men); **Criteria for transfusion** = not defined	Characteristi cs similar across groups	First 50 patients for robotic surgery group compared with last 50 of open surgery group; reason for assignment to type of surgery NR	**Periop:** DVT, extended intubation, ileus/small bowel obstruction, prolonged abdominal swelling, prolonged drain output, anastomotic urine leak, significant gross hematuria, EKG changes during anesthesia, peritoneal hematoma, pneumonia, bladder neck contracture, gastric ulcer, meatal stenosis, bladder stone, migrated Weck clip, significant gross hematuria requiring endoscopic clot

Table A2: Prostatectomy; Additional Characteristics of Included Studies					
Study	**Surgeon Expertise and Learning Curve**	**Outcome Definitions (operative time, continence, sexual function, criteria for transfusion)**	**Patient Character-istic Difference s for Each Arm**	**Patient Assignment**	**Reporting of Complications**
					evacuation, urine leak, inguinal hernia, non-ST-segment elevation, MI
Nelson, 2007[55]	NR	None of these outcomes were reported	No statistically significant differences	Prospective. Consecutive patients within a certain time period. Patient decision on type of procedure after consulting with surgeon	**Postop:** post-catheter retention, lymphocele, wound infection, DVT, PE, urinary tract infection, ileus, epididymitis, clot retention, urinary leakage/urinoma, port hernia, rectal injury, postop hemorrhage, fever
O'Malley, 2006[56]	Surgeons had no previous laparoscopic experience. No specific numbers are provided for the learning curve as a whole. Individual surgeon's operating time levelled off between the 20th and 40th case; the step of urethra-vesical anastomosis formation and operating room preparation and robot set-up both take approximately 10 cases	None of these outcomes were reported	No statistically significant differences for the characteristic s provided	NR	**NR**
Ou, 2009[57]	Single surgeon did not appear to have previous experience; initial 30 patients for robotic surgery. A learning curve of 30 cases was required for the surgeon to acquire a console time of < 3 hrs. and vesicourethral anastomosis time of 40 min.	None defined	Only significant difference was age, which was significantly higher in RRP group	Retrospective. Consecutive patients within a certain time period. Patient decision on type of procedure after consulting with surgeon	**Postop:** lymph leakage; vesicourethral anastomosis stricture; vesicourethral anastomosis leakage. **Intraop:** Bladder injury, rectal injury, vesicourethral anastomosis tear, bleeding

Table A2: Prostatectomy; Additional Characteristics of Included Studies					
Study	**Surgeon Expertise and Learning Curve**	**Outcome Definitions (operative time, continence, sexual function, criteria for transfusion)**	**Patient Character-istic Difference s for Each Arm**	**Patient Assignment**	**Reporting of Complications**
Ploussard, 2009[73]	Two experienced surgeons performed LRP; robotic surgery was performed by a surgeon with prior LRP experience. No information provided about learning curve	**Oper time** = total time in operating room; **Other outcomes** = not defined	No statistically significant differences	Prospective. Consecutive patients within a certain time period; reason for assignment to type of surgery NR	**Postop:** Urinary infection or sepsis, retention, renal insufficiency, pelvic hematoma, postop bleeding, anastomotic leakage. **Intraop:** rectal injury
Prewitt, 2008[58]	NR	None of these outcomes were reported	Patient characteristic s not reported	NR	NR
Rocco, 2009[59]	3 surgeons, all laparoscopic surgery naïve. No information provided about learning curve	**Oper time** = skin to skin; **Continence** = no pad use, or only 1 safety pad; **Sexual function** = ability to have complete sexual intercourse with or without use of oral phosphodiesteras e-5 inhibitors; **Transfusions** = NR	All characteristic s comparable except higher percentage of patients with pT3/pT4 disease in RRP group	Prospective RALP and retrospective RRP. Consecutive patients within a certain time period. Patient decision on procedure after consulting with surgeon	NR
Rozet, 2007[74]	NR	**Oper time** = entire procedure; **Continence** = NR; **Sexual function** = NR; **Criteria for transfusion** = not defined	Patients were match-paired with no statistical differences	Prospective. All patients within a certain time period; reason for assignment to type of surgery NR	**Postop:** anastomotic leakage, wound abscess, infected pelvic hematoma, urinary infection, postop bleeding, retention, anastomotic leakage, urinary sepsis, pulmonary embolism, renal insufficiency. **Intraop:** robotic surgery converted to laparoscopic for dissection difficulties

Table A2: Prostatectomy; Additional Characteristics of Included Studies					
Study	**Surgeon Expertise and Learning Curve**	**Outcome Definitions (operative time, continence, sexual function, criteria for transfusion)**	**Patient Character-istic Differences for Each Arm**	**Patient Assignment**	**Reporting of Complications**
Schroeck, 2008[60]	NR	None of these outcomes were reported	Patients undergoing RALP had significantly lower clinical stage, biopsy and pathological Gleason scores, risk, and fewer had seminal vesical invasion	Retrospective. All patients within a certain time period. Decision on procedure at the discretion of patients and attending urologists	NR
Smith, 2007[61]	Surgeon expertise was considered sufficient because last 200 consecutive cases chosen from each of 1,238 robotic surgery and 509 open surgery	None of these outcomes were reported	PSA significantly higher in open surgery group. Robotic surgery group had statistically higher proportion of more favourable clinical stage and lower Gleason score	Retrospective. Consecutive patients within a certain time period; reason for assignment to type of surgery NR	NR
Srinualnad, 2008[75]	Surgeon had previous experience with laparoscopic prostatectomy. No information provided on learning curve	**Oper time =** not defined; **Continence =** pad-free at one month; **Sexual function** = NR; **Transfusions =** NR	No demographic differences between the 2 arms	NR	**Periop:** UTI, urinary retention after catheter removal, pulmonary emboli, ureteric injury

Table A2: Prostatectomy; Additional Characteristics of Included Studies					
Study	**Surgeon Expertise and Learning Curve**	**Outcome Definitions (operative time, continence, sexual function, criteria for transfusion)**	**Patient Character-istic Difference s for Each Arm**	**Patient Assignment**	**Reporting of Complications**
Tewari, 2003[62]	Surgeons performing retropubic surgeries had >1400 procedures combined; robotic expertise NR. No information provided on learning curve	**Oper time** = from dissection or incision to closure; **Continence** = no pads, or use of liner for security reasons only; **Sexual function** = ability to obtain an erection and have sexual intercourse; **Criteria for transfusion** = not defined	Patients had comparable characteristic s	Prospective. All patients who consented within a certain time period (if they had 10-year life expectancy, and Gleason score ≥6). Personal preference of patient for procedure	**Postop:** postop ileus, wound dehiscence/hernia, postop fever/pneumonia, lymphocele, obturator neuropathy, DVT, postop MI, postop bleeding/re-exploration. **Intraop:** rectal injury, aborted procedure
Trabulsi, 2008[76]	NR	None of these outcomes were reported	Patients had comparable characteristic s except BMI significantly higher in robotic surgery group	Retrospective. Consecutive patients within a certain time period; reason for assignment to type of surgery NR	NR
Trabulsi, 2010[77]	Surgeon expertise NR; Single surgeon with experience in laparoscopic surgery; initial 205 patients undergoing robotic surgery. No information provided for learning curve with robotic surgery	**Oper time** = incision to end of surgery; **Continence** = completely without leakage, or use of a pad socially for protection only; **Sexual function** = potency defined as ability to achieve and sustain an erection satisfactory for intercourse with or without PDE-5 inhibitors;	Patients had comparable characteristic s	Retrospective. Consecutive patients within a certain time period; reason for assignment to type of surgery NR	NR

Table A2: Prostatectomy; Additional Characteristics of Included Studies					
Study	**Surgeon Expertise and Learning Curve**	**Outcome Definitions (operative time, continence, sexual function, criteria for transfusion)**	**Patient Character-istic Difference s for Each Arm**	**Patient Assignment**	**Reporting of Complications**
		Criteria for transfusion = not defined			
Truesdale, 2010[63]	Surgeon expertise NR; all surgeons were high-volume. No information provided for learning curve	**Oper time =** not defined; **Other outcomes** were not reported	Robotic surgery patients were significantly younger and significantly fewer had intermediate or high-risk disease compared with the open group	All patients undergoing radical prostatectomy by the 5 surgeons within a specified time period; reason for assignment to type of surgery NR	NR
Webster, 2005[64]	NR	None of these outcomes were reported	Patients had comparable characteristic s except PSA statistically higher in retropubic surgery group	Prospective. All patients in a certain time frame. Patient decision for procedure after consulting with surgeon	NR
White, 2009[65]	Single surgeon experienced in retropubic surgery, but no experience with robotics. Study was conducted during the learning curve, which was assumed to be 50 patients, based on the published data.	None of these outcomes were reported	Patients had comparable characteristic s except robotic surgery group had statistically significant lower low-risk and increased moderate-risk patients	Retrospective. Consecutive patients within a certain time period for robotics. Matched cohort for retropubic; reason for assignment to type of surgery NR	NR

Table A2: Prostatectomy; Additional Characteristics of Included Studies					
Study	**Surgeon Expertise and Learning Curve**	**Outcome Definitions (operative time, continence, sexual function, criteria for transfusion)**	**Patient Character-istic Difference s for Each Arm**	**Patient Assignment**	**Reporting of Complications**
Williams, 2010[66]	High volume surgeons with extensive experience. Learning curve may have been partially incorporated into the study, as positive margin rates decreased throughout	None of these outcomes were reported	Significantly more men in open surgery group had palpable disease	Type of surgery was based solely on the surgeon whom patient was referred to	NR
Wood, 2007[67]	NR	None of these outcomes were reported	Patients had comparable characteristic s	Prospective. All patients in a certain time period who gave consent; reason for assignment to type of surgery NR	NR
Zorn, 2009[68]	NR	No outcome definitions were given	Patient characteristic s were only given in usable data for the robotic surgery group	Consecutive patients were chosen for the study; reason for assignment to type of surgery NR	

CVA=cerebrovascular accident; DVT=deep vein thrombosis; hr-hour; EKG=electrocardiogram; IIEF-5=erectile dysfunction test; intraop=intraoperative; MI=myocardial infarct; NR=not reported; oper=operative; OR=operating room; PACU=post-anesthesia care unit; periop=perioperative; postop=postoperative; preop=preoperative; PSA=prostate specific antigen; QoL=quality of life; UTI=urinary tract infection; wk=week

Table A3: Nephrectomy; Additional Characteristics of Included Studies					
Study	**Surgeon Expertise and Learning Curve**	**Outcome Definitions (operative time, criteria for transfusion)**	**Patient Characteristic Differences for Each Arm**	**Patient Assignment**	**Reporting of Complications**
Aron, 2008[106]	No previous experience with robotic surgery. No information provided for learning curve	**Oper time** = operating room time; **Transfusions** = NR	No statistically significant differences	Prospective robotic surgery patients were specially selected (on basis of a single small unilateral renal mass). Laparoscopic group was matched retrospectively to robotic surgery group	NR
Benway, 2009[107]	Surgeons were experienced in laparoscopic renal surgery. No information provided for learning curve, but initial cases of robotic surgery were included	**Oper time** = overall operative time; **Criteria for transfusion** = not defined	No statistically significant differences	Retrospective comparison of consecutive patients.; reason for assignment to type of surgery NR	**Postop:** urine leaks, pulmonary embolus, MI, rectus hematoma, arteriovenous malformations, subcapsular hematoma, C. difficile colitis, hematoma, ileus, fever, scapular abrasion. **Intraop:** adrenal injury prompting ipsilateral adrenalectomy; conversions to open surgery
Deane, 2008[108]	Surgeon performing robotic surgery had no robotic experience; laparoscopic surgeons were experienced. Initial cases of robotic surgery were included	**Oper time** = total operative time; **Criteria for transfusion** = not defined	Appear to be comparable (statistical significance not provided)	Retrospective comparison of consecutive patients; reason for assignment to type of surgery NR	**Postop:** hemorrhage. **Intraop:** urinary extravastation
DeLong, 2010[109]	Surgeon expertise NR. Initial cases of robotic surgery were included and were considered to be	**Oper time =** total time in OR; **Criteria for transfusion =** NR	No statistically significant differences	Study included all patients of one surgeon in a specific time period; reasons for assignment to type of surgery NR	**Periop:** readmission for congestive heart failure which resolved after diuresis, UTI, readmission for postop bleeding,

Table A3: Nephrectomy; Additional Characteristics of Included Studies					
Study	**Surgeon Expertise and Learning Curve**	**Outcome Definitions (operative time, criteria for transfusion)**	**Patient Characteristic Differences for Each Arm**	**Patient Assignment**	**Reporting of Complications**
	within the learning curve				COPD exacerbation requiring readmission, conversions to radical nephrectomy
Haber, 2010[110]	Surgeon expertise NR. Initial cases of robotic surgery were included and were considered to be within the learning curve	Outcome definitions NR	No statistically significant differences	Consecutive patients for robotic surgery matched with laparoscopic surgery patients	**Periop:** prolonged ileus, transient syncopal episode, atrial fibrillation ,DVT, urinoma, angioembolization for persistent postop bleeding, conversions to laparoscopy, conversion to open
Hemal, 2009[111]	Single surgeon experienced in robotic and laparoscopic surgery. No information provided for learning curve	**Oper time** = not defined; **Criteria for transfusion** = not defined	No statistically significant differences	Prospective robotic surgery group matched with a contemporary laparoscopic surgery cohort (single surgeon for both groups). Patient's choice of procedure	**Postop:** bowel, wound infection, delayed bleeding, atelectasis, ileus, incisional hernia. **Intraop:** vascular hemorrhage, renal arterial bleed, uncontrolled bleeding due to tumour location required conversion to open
Jeong, 2009[112]	Surgeon expertise NR; Single surgeon for robotic surgery group. Initial cases of robotic surgery were included and were considered to be within the learning curve	**Oper time** = not defined; **Criteria for transfusion** = not defined	No statistically significant differences	Appears to be a prospective comparison of all patients in a particular time period; reason for assignment to type of surgery NR	NR
Kural, 2009[113]	Surgeon expertise NR. No information provided for learning curve	**Oper time** = not defined; **Criteria for transfusion** = not defined	No statistically significant differences	Appears to be a prospective comparison of all patients in a particular time period; reason for assignment to type of surgery NR	**Postop:** Renal arterial pseudoaneurysm, excessive postop bleeding

Table A3: Nephrectomy; Additional Characteristics of Included Studies					
Study	**Surgeon Expertise and Learning Curve**	**Outcome Definitions (operative time, criteria for transfusion)**	**Patient Characteristic Differences for Each Arm**	**Patient Assignment**	**Reporting of Complications**
Nazemi, 2006[115]	Surgeon expertise NR; Single surgeon. No information provided for learning curve	**Oper time** = not defined; **Criteria for transfusion** = not defined	No statistically significant differences	Prospective comparison of all patients in a particular time period by a single surgeon; reason for assignment to type of surgery NR	**Postop:** *C.difficile* colitis, pneumonia, pneumothorax, , enterocutaneous fistula, wound dehiscence, MI. **Intraop:** staple failure resulting in renal vein bleed, perforated duodenum, brachial plexus injury
Wang, 2009[114]	Surgeon expertise NR; surgeon was experienced in minimally invasive surgery. Initial cases of robotic surgery were included and were considered to be within the learning curve	**Oper time** = first incision for placement of the Veress needle to placement of the dressing (including trocar placement, robot docking); **Criteria for transfusion** = not defined	No statistically significant differences	Retrospective comparison of consecutive patients of a single surgeon. First 62 patients underwent LPN, next 40 patients underwent RPN	**Postop:** Cardiopulmonary, thromboembolic, hematoma, transfusion, pseudoaneurysm, cystoscopy and stent, exploration. **Intraop**: conversions to alternate surgeries

DVT=deep vein thrombosis; intraop=intraoperative; MI=myocardial infarct; NR=not reported; oper=operative; postop=postoperative

Table A4: Hysterectomy; Additional Characteristics of Included Studies					
Study	**Surgeon Expertise and Learning Curve**	**Outcome Definitions (operative time, criteria for transfusion)**	**Patient Characteristic Differences for Each Arm**	**Patient Assignment**	**Reporting of Complications**
Bell, 2008[102]	Surgeon expertise NR, but it appears that initial laparoscopic and robotic surgery cases were included. Single surgeon;	**Oper time** = not defined; **Criteria for transfusion** = not defined	Laparotomy group statistically significantly older than other 2 groups	Retrospective study of all patients for a single surgeon within a given time period. NR how procedure was chosen for each patient, but once laparoscopy and robotic procedures available, only	**Postop:** Ileus, wound infection, lymphedema, vaginal cuff hematoma, port site hernia, re-op for bleeding, delayed voiding, DVT, vaginal cuff dehiscence, superficial phlebitis, atrial fibrillation. **Intraop:** damage to genital formal nerve,

Table A4: Hysterectomy; Additional Characteristics of Included Studies					
Study	**Surgeon Expertise and Learning Curve**	**Outcome Definitions (operative time, criteria for transfusion)**	**Patient Characteristic Differences for Each Arm**	**Patient Assignment**	**Reporting of Complications**
				patients requesting laparotomy were operated on using laparotomy procedure	injury of vena cava, incisional hernia
Boggess, 2008[103]	Surgeon expertise NR, although robotic system was new. No information provided for learning curve	**Oper time** = skin to skin; **Criteria for transfusion** = not defined	BMI in robotic surgery group significantly higher than laparotomy surgery group	Prospective robotic surgery group from certain time period compared with historical cohorts; reason for assignment to type of surgery NR	**Postop:** number of complications given, but not specified. **Intraop:** bowel leak, enterotomy; other intraoperative complications # given but not specified
Boggess, 2008[80]	Surgeon expertise NR, although robotic system was new. No information provided for learning curve	**Oper time** = skin to skin; **Criteria for transfusion** = not defined	Age in robotic surgery group significantly higher than open surgery group	Prospective, consecutive patients in robotic surgery group compared with historical cohort; reason for assignment to type of surgery NR	Only complication rate given; no complications specified
Cantrell, 2010[81]	Surgeon expertise NR, although robotic system was new. No information provided for learning curve	**Oper time** = from start of the first side wall to vaginal cuff closure; **Transfusions** = NR	No statistical differences	Retrospective study of patients in a certain time frame; reason for assignment to type of surgery NR	**Postop:** ICU admission, cuff dehiscence requiring re-operation, return to OR for obturator vein bleeding on POD, ileus. **Intraop:** asystole
Cardenas-Goicoechea, 2010[94]	Surgeon expertise NR; single surgeon; Initial cases of robotic surgery were included and were considered to be within the learning curve	**Oper time** = Veress needle insertion/skin incision to skin closure; **Criteria for transfusion** = not defined	No statistical differences	Retrospective study of patients in a certain time frame; reason for assignment to type of surgery NR	**Postop:** pulmonary embolism, enterocutaneous fistula, lymphocele, UTI, pneumonia, wound seroma, vaginal cuff cellulitis, vaginal cuff dehiscence, pelvic abscess, incisional hernia, nausea/vomiting, small bowel obstruction, hematoma, port site

Table A4: Hysterectomy; Additional Characteristics of Included Studies					
Study	**Surgeon Expertise and Learning Curve**	**Outcome Definitions (operative time, criteria for transfusion)**	**Patient Characteristic Differences for Each Arm**	**Patient Assignment**	**Reporting of Complications**
					abscess. **Intraop:** # of complications given but not specified
DeNardis, 2008 [82]	Surgeon expertise NR, although robotic system was new. Initial cases of robotic surgery were included and were considered to be within the learning curve	**Oper time for open hyster** = skin to skin; **Oper time for robotic** = placement of uterine manipulator to skin closure; **Criteria for transfusion** = not defined	Robotic surgery group significantly younger and thinner (lower BMI) than open surgery group	Prospective, consecutive patients in robotic surgery group compared with historical cohort.	**Postop:** fever; anemia requiring transfusion; ileus; acute renal failure/acute tubular necrosis; pulmonary embolism; C. difficile colitis; anemia not requiring transfusion; urinary retention requiring catheter; thrush; UTI; atelectasis; lymphocele; vaginal cuff hematoma/ cuff separation; respiratory failure requiring mechanical ventilation; atelectasis; wound infection /seroma /hematoma
Estape, 2009[104]	NR	**Oper time** = insertion of foley catheter and closing of last trocar site; **Criteria for transfusion** = not defined	Mean age of patients in robotic group statistically higher than laparotomy group; other parameters same	Prospective, consecutive patients in robotic surgery group compared with historical cohort (matched by stage and type of cancer).	**Postop:** COPD/atelectasis, fever, hypokalemia, ileus, wound cellulitis, pelvic abscess, pneumonia, SVT, ureter dilation, urine retention, UV fistula, vaginal evisceration. **Intraop:** cystotomy

Table A4: Hysterectomy; Additional Characteristics of Included Studies					
Study	**Surgeon Expertise and Learning Curve**	**Outcome Definitions (operative time, criteria for transfusion)**	**Patient Characteristic Differences for Each Arm**	**Patient Assignment**	**Reporting of Complications**
Feuer, 2010[83]	Single surgeon with 20 previous robotic surgeries; cases of robotic surgery included and were considered to be within the learning curve based on operative times	**Oper time** = skin to skin; **Criteria for transfusion =** not defined	No significant differences	Consecutive patients; reason for assignment to type of surgery NR	**Postop:** cholecystitis, pelvic abscess, UTI, hematoma, ileus
Gehrig, 2008[95]	NR	**Oper time** = not defined; **Transfusions** = NR	No statistically significant differences	Consecutive patients in robotic surgery group compared with historical cohort of laparoscopic surgeries	**Postop:** Lymphedema/lymphocyst, port-site hernia, enterotomy, vaginal cuff complication, transient neuropathy. **Intraop:** laparoscopic surgery converted to open
Geisler, 2010[84]	Robotic system was new but surgeons experienced robotics were used in most cases (after 50 surgeries). It was stated that the study cases were incorporated after the learning curve was overcome	**Oper time** = not defined; **Transfusions** = NR	Only age and BMI given; no statistically significant difference	Prospective, consecutive patients in robotic surgery group compared with consecutive historical cohort.	**Postop:** Urinary retention
Gocmen, 2010[85]	Surgeons had extensive laparoscopic experience but do not appear to have had experience with robotic surgery. No information on learning curve was provided.	**Oper time =** Setup time plus total time on the console for robotic group; Skin to skin for laparotomy group; **Criteria for transfusion** = not defined	Characteristics similar for both arms	Patient decision following consultation	**Periop**: Intraoperative vaginal laceration, spleen capsule rupture, incisional hernia, incision leakage requiring antibiotics

Table A4: Hysterectomy; Additional Characteristics of Included Studies					
Study	**Surgeon Expertise and Learning Curve**	**Outcome Definitions (operative time, criteria for transfusion)**	**Patient Characteristic Differences for Each Arm**	**Patient Assignment**	**Reporting of Complications**
Halliday, 2010[86]	NR	**Oper time =** surgery time; **Criteria for transfusion =** not defined	No significant differences	Prospective, consecutive patients in robotic surgery group compared with historical cohort	**Periop:** fever, wound complications, UTI, CVS, DVT, ileus/bowel obstruction, poor HTN control, post op ER visits, readmissions, bladder dysfunction, C. difficile diarrhea
Holtz, 2010[96]	Surgeon expertise NR, but robotic system was new. No information on learning curve was provided	**Oper time =** surgery time; **Transfusions =** NR	BMI significantly greater in patients undergoing robotic surgery	Type of surgery dictated by availability of robot on date of surgery	**Periop:** cystitis with urine retention, partial Obturator nerve injury, subcutaneous emphysema, enterotomy with conversion, ureteral ligation, conversions to open
Jung, 2010[105]	NR	**Oper time =** beginning of skin incision to completion of skin closure; **Criteria for transfusion =** not defined	No statistically significant differences in mean age and BMI	Uterine size and financial capability for covering costs of minimally invasive surgery	**Intraop:** external iliac vein injury **Postop:** pelvic infections, ureteral stricture, ileus, incisional hernia, wound dehiscence, lymphocele, lymph edema
Ko, 2008[87]	Surgeon expertise NR; robotic surgeries performed by 2 senior gynecology/oncology surgeons, but experience NR. Cases of robotic surgery were considered to be within the learning curve	**Oper time** = not defined; **Criteria for transfusion** = not defined	No statistically significant differences	Retrospective series of patients in a specific time period; reason for assignment to type of surgery NR	**Postop:** Vaginal cuff abscess, ureterovaginal fistula, pelvic lymphocele, partial small bowel obstruction and mesenteric abscess, postop ileus, pulmonary embolus, wound infection, wound dehiscence. **Intraop:** ureteral transection
Lowe, 2010[88]	Surgeon in robotic surgery arm had advanced laparoscopic training and 5 previous robotic	**Oper time =** beginning of skin incision to completion of skin closure; **Criteria for transfusion** = not	Reported as no significant difference	Patient decision for procedure following consultation with surgeon	**Periop:** cuff separation, vulvar edema, bowel obstruction, postop hemorrhage, fascial dehiscence requiring reoperation, acute

Table A4: Hysterectomy; Additional Characteristics of Included Studies					
Study	**Surgeon Expertise and Learning Curve**	**Outcome Definitions (operative time, criteria for transfusion)**	**Patient Characteristic Differences for Each Arm**	**Patient Assignment**	**Reporting of Complications**
	surgeries; surgeons in open surgery arm were experienced. No information on learning curve was provided.	defined			renal failure, postop ICU admission
Maggioni, 2009[89]	No previous robotic or laparoscopic experience. No information on learning curve was provided.	**Oper time** = skin to skin; **Criteria for transfusion** = not defined	Robotic surgery group significantly younger; no other statistically significant differences	Prospective group of patients in robotic surgery group compared with historical matched cohort.	**Postop:** subcutaneous emphysema, fever, infection, vaginal discharge, ileus, temporary palsy of obturator nerve, pleural effusion, re-intervention, lower extremity edema, vaginal dehiscence, incisional hernia, lymph cyst, re-admission. **Intraop:** Nerve injury, bladder injury, intestinal injury, vascular injury
Nevadunsky, 2010[90]	Surgeon expertise NR, although robotic system was new. No information on learning curve was provided.	**Oper time =** surgery time; **Criteria for transfusion =** not defined	No statistically significant differences	Retrospective comparison of consecutive patients; reason for assignment to type of surgery NR	**Postop:** UTI, vaginal cuff separation, pulmonary embolism, SICU admission, wound infection
Nezhat, 2009[97]	NR	**Oper time** = skin to skin (docking times also provided); **Transfusions** = none	No statistically significant differences	Prospective, consecutive patients in robotic surgery group compared with matched historical cohort in same time period; reason for assignment to type of surgery NR	NR

Table A4: Hysterectomy; Additional Characteristics of Included Studies					
Study	**Surgeon Expertise and Learning Curve**	**Outcome Definitions (operative time, criteria for transfusion)**	**Patient Characteristic Differences for Each Arm**	**Patient Assignment**	**Reporting of Complications**
Payne, 2008[98]	Surgeon expertise NR, although robotic system was new (learning curve addressed by subanalysis of operative time for last 25 robotic cases)	**Oper time** = skin to skin; **Transfusions** = NR	No statistically significant differences	Retrospective study; consecutive patients in robotic group compared with consecutive cohort; reason for assignment to type of surgery NR	NR
Schreuder, 2010[91]	NR	**Oper time =** start of anesthetic preparations to patient leaving the operating table; **Criteria for transfusion =** NR	No statistically significant differences	Study included all patients within a specific time period; reason for assignment to type of surgery NR	**Periop:** accessory ureter was cut requiring a 2nd procedure, cystotomy lesion managed conservatively, temporary ureteric obstruction, vault abscess
Seamon, 2009[99]	NR	**Oper time** = room to incision time, room time, and skin time; **Criteria for transfusion** = not defined	Robotic surgery group statistically significantly higher BMI; no other statistically significant differences	Retrospective study; all patients in robotic surgery group compared with consecutive historical cohort.	**Postop:** venous thromboembolic events, cardiac events, pulmonary events, neurologic events. **Intraop:** Major vessel injury, nerve injury, GI injury, urinary tract injury
Seamon, 2009[92]	Surgeon expertise NR, although robotic system was new. No information on learning curve was provided.	**Oper time** = total OR time and skin to skin; **Criteria for transfusion** = not defined	Robotic surgery group younger and more had at least 3 comorbidities	Retrospective study; all obese patients in robotic surgery group in given time period compared with consecutive historical cohort of obese patients in a different time period.	**Postop:** venous thromboembolic events, cardiac events, pulmonary events, neurologic events, urologic events, fever, acute renal failure, paresthesias, fistula workup, postop bleeding, death, cardiac arrest. **Intraop:** major vessel injury, major nerve injury, GI injury

Table A4: Hysterectomy; Additional Characteristics of Included Studies					
Study	**Surgeon Expertise and Learning Curve**	**Outcome Definitions (operative time, criteria for transfusion)**	**Patient Characteristic Differences for Each Arm**	**Patient Assignment**	**Reporting of Complications**
Sert, 2007[100]	NR	**Oper time** = console time for robotic; docking time also provided; **Transfusions** = NR	No statistically significant differences	Retrospective study; all patients in a given time period (different periods for robotic and laparoscopic)	**Postop and intraop listed together:** UTI, lymphocyst, cystostomy, compartment syndrome
Shashaua, 2009[101]	Surgeon expertise NR; single surgeon. No information on learning curve was provided.	**Oper time** = NR, but OR time also provided; **Transfusions** = NR	No statistically significant differences	Retrospective study; all patients in a given time period (different periods for robotic and laparoscopic)	NR
Veljovich, 2008[93]	Appears that surgeons had no previous robotic experience. No information on learning curve was provided.	**Oper time** = not defined; **Transfusions** = NR	No statistically significant differences	Prospective robotic surgery group from specific time period compared with historical cohorts.	NR

BMI=body mass index; DVT=deep vein thrombosis; ICU=intensive care unit; intraop=intraoperative; NR=not reported; oper=operative; OR=operating room; periop=perioperative; postop=postoperative; UTI=urinary tract infection

Table A5: Cardiac Surgery; Additional Characteristics of Included Studies					
Study	**Surgeon Expertise and Learning Curve**	**Outcome Definitions (operative time, criteria for transfusion)**	**Patient Characteristic Differences for Each Arm**	**Patient Assignment**	**Reporting of Complications**
Ak, 2007[116]	NR	**Oper time** = skin to skin; **Transfusions** = NR	No statistically significant differences	Retrospective comparison of all ASD patients in a particular time period. Patient preference and gender (female patients preferred RAST for cosmetic reasons) decided type of surgery	NR

Table A5: Cardiac Surgery; Additional Characteristics of Included Studies					
Study	**Surgeon Expertise and Learning Curve**	**Outcome Definitions (operative time, criteria for transfusion)**	**Patient Characteristic Differences for Each Arm**	**Patient Assignment**	**Reporting of Complications**
Folliguet, 2006[118]	Surgeon expertise NR; single surgeon for sternotomy and single console surgeon for robotic group. No information on learning curve was provided.	**Oper time** = total procedure time, and also lists separately time for various sections of the surgery; **Criteria for transfusion** = not defined	No statistically significant differences	Prospective comparison of patients undergoing robotic surgery in a particular time period matched retrospectively with control group	**Post-op:** reoperations for bleeding, TIA, groin lymphocele, pulmonary pleural effusion, reoperations for MR, peripheral embolus **Intraop**: Conversion to thoracotomy
Kam, 2010[119]	Surgeon expertise NR; first year of robotic surgery was excluded to minimise learning curve bias. No additional information on learning curve was provided.	**Oper time =** total procedure time; **Criteria for transfusion =** NR	No statistically significant differences	All patients with MVR over a specific time period; reason for assignment to type of surgery NR	**Post op:** bleeding, reoperations, inpatient rehabilitation
Mihaljevic, 2011[120]	Reported that all surgeons were highly experienced in repair techniques	**Oper time =** not defined; **Criteria for transfusion =** not defined	Propensity matching was used for outcome analysis	Retrospective comparison of patients undergoing surgery in a particular time period; type of surgery was surgeons' preference	**Periop:** reoperation for bleeding, transfusions, stroke, new-onset atrial fibrillation/flutter, hypoperfusion, ventilated > 24 hours, pleural effusion
Morgan, 2004[117]	NR	**Oper time** = bypass time; **Criteria for transfusion** = not defined	No statistically significant differences	Prospective comparison of patients undergoing surgery in a particular time period	Report only that there were no major complications (stroke, sternal wound infection, bleeding respiratory failure, renal failure)

Table A5: Cardiac Surgery; Additional Characteristics of Included Studies					
Study	**Surgeon Expertise and Learning Curve**	**Outcome Definitions (operative time, criteria for transfusion)**	**Patient Characteristic Differences for Each Arm**	**Patient Assignment**	**Reporting of Complications**
Poston, 2008[123]	NR	**Oper time** = not defined; **Criteria for transfusion** = not defined	No statistically significant differences	Prospective comparison of patients undergoing robotic surgery in a particular time period matched retrospectively with control group. Disease state determined patient suitability for robotic mini-CABG; scores for propensity to perform mini-CABG used to match control group of patients	**Post-op**: mortality, MI, stroke, need for revascularization, major infection, renal failure, reoperation for bleeding, prolonged ventilation, atrial fibrillation, 30-day readmittance
Tabata, 2006[121]	NR	**Oper time** = times given for cardiopulmonary bypass time and mean aortic cross-clamp time; **Criteria for transfusion** = not defined	Mean age of robotic surgery group significantly lower, but no other statistics given for robotic group characteristics; **IMPORTANT NOTE**: only 5 robotics patients; 123 control group patients	Retrospective comparison of all minimally invasive surgery for elderly patients in a particular time period; reason for assignment to type of surgery NR	**Post-op**: mortality, atrial fibrillation, bleeding requiring re-exploration, stroke, pulmonary insufficiency, wound infection, pacemaker implantation, re-operation (long-term)
Woo, 2006[122]	Surgeon expertise NR; single surgeon. No information on learning curve was provided.	**Oper time** = times given for cardiopulmonary bypass time, mean aortic cross-clamp time, and time to extubation; **Criteria for transfusion** = not defined	No statistically significant differences	Retrospective comparison of consecutive mitral valve surgical patients in a particular time period. Surgical procedure chosen primarily at request of referring physician or patient	**Post-op**: death, re-exploration for bleeding, sternal wound infection

ASD=atrial septal defect; CABG=coronary artery bypass grafting; intraop=intraoperative; MVR=mitral valve repair; NR=not reported; oper=operative; postop=postoperative; RAST=right anterior small thoracotomy

Appendix 8: Patient Characteristics

Table A6: Patient Characteristics — Prostatectomy								
First Author, Year; Design	**Inclusion/ Exclusion Criteria**	**Comparison Arms**	**No. of Pts.**	**Age (years)**	**BMI (kg/m^2)**	**Pre-op PSA (ng/mL)**	**Gleason Score**	**Clinical Stage**
Ahlering, 2004;[29] Retrospective comparison	NR	Da Vinci	60	Mean 62.9 (range 43-78)	Mean 26.3 (range 20.6-33.6)	Mean 8.1 (range 0.1-62)	≤ 6: 33 (55%) 3 + 4: 16 (27%) 4 + 3: 4 (7%) 8-10: 7 (11%)	T1c: 38 (63%) T2a: 19 (33%) T2b: 2 (3.3%) T3a: 1 (0.7%)
		Open radical prostatectomy	60	Mean 62.7 (50-78) (P=NS)	Mean 26.5 (20-34.5) (P=NS)	Mean 8.4 (1.1-39.6) (P=NS)	≤ 6: 31 (52%) 3 + 4: 13 (22%) 4 + 3: 7 (12%) 8-10: 9 (15%)	T1c: 36 (60%) T2a: 23 (38%) T2b: 0 T3a: 1 (2%)
Ball, 2006;[78] Prospective observational	Men with newly diagnosed, clinically localized prostate cancer	Da Vinci	82	Mean 60 ± 7 (SD) (range 40-73)	NR	Mean 6.0 ± 2.4 (SD) (range 1.0-14.0)	2-6: 59 (72%) 7: 15 (18%) 8-10: 8 (10%)	T1: 66 (80%) T2: 15 (18%) T3: 1 (1%)
		Open radical prostatectomy	135	Mean 59 ± 6 (SD) (range 34-72)	NR	Mean 7.8 ± 5.6 (SD) (range 1.0-32.5)	2-6: 85 (63%) 7: 37 (27%) 8-10: 13 (10%)	T1: 116 (86%) T2: 19 (14%) T3: 0
		Laparoscopic radical prostatectomy	124	Mean 61 ± 7 (SD) (range 42-74)	NR	Mean 7.2 ± 7.1 (SD) (range 0.1 - 69.6)	2-6: 94 (76%) 7: 22 (18%) 8-10: 8 (6%)	T1: 100 (81%) T2: 24 (19%) T3: 0
Barocas, 2010;[30] Prospective observational	Men with localized prostate cancer	Da Vinci	1413	Mean 61 ± 7.3 (SD)	NR	Median 5.4 (IQR 4.3-7.4)	≤ 6: 986 (69.9%) 7: 353 (25.0%) 8-10:72 (5.1%)	NR
		Retropubic radical prostatectomy	491	Mean 62 ± 7.3 (SD)	NR	Median 5.8 (IQR 4.6-8.4)	≤ 6: 327 (66.6%) 7: 116 (23.6%) 8-10:48 (9.8%)	NR

Table A6: Patient Characteristics — Prostatectomy								
First Author, Year; Design	**Inclusion/ Exclusion Criteria**	**Comparison Arms**	**No. of Pts.**	**Age (years)**	**BMI (kg/m^2)**	**Pre-op PSA (ng/mL)**	**Gleason Score**	**Clinical Stage**
Boris, 2007;[31] Retrospective comparison	Men with localized prostate cancer	Da Vinci	50	Mean 59.8 ± 7.47 (SD)	Mean 28.8 ± 4.3 (SD)	Mean 6.6 ± 4.20 (SD)	≤ 6: 29 (58%) 3+4: 13 (26%) 4+3: 4 (8%) 8-10: 4 (8%)	T2a: 2 (4%) T2b: 11 (22%) T2c: 21 (42%) T3a: 15 (30%) T3b: 1 (2%) T3c: 0
		Retropubic radical prostatectomy	50	Mean 61.7 ± 7.12 (SD)	Mean 27.5 ± 2.59 (SD)	Mean 8.8 ± 7.01 (SD)	≤ 6: 32 (62%) 3+4: 12 (24%) 4+3: 1 (2%) 8-10: 5 (10%)	T2a: 4 (8%) T2b: 30 (46%) T2c: 9 (18%) T3a: 11 (22%) T3b: 2 (4%) T3c: 1 (2%)
		Perineal radical prostatectomy	50	Mean 61.8 ± 7.96 (SD)	Mean 29.4 ± 5.2 (SD)	Mean 5.8 ± 3.88 (SD)	≤ 6: 29 (58%) 3+4: 25 (30%) 4+3: 2 (4%) 8-10: 2 (4%)	T2a: 7 (14%) T2b: 30 (60%) T2c: 3 (6%) T3a: 8 (16%) T3b: 2 (4%) T3c: 0
Breyer, 2010;[32] Prospective observational	Men with clinically localized prostate cancer with follow up of at least 12 months	Da Vinci	293	Mean 59.7 ± 7.11 (SD)	NR	Mean 7.1 ± 5.39 (SD)	6 (3+3): 166 (58%) 7 (3+4): 70 (24%) 7 (4+3): 29 (10%) 8-10: 23 (8%)	NR
		Open radical prostatectomy	695	Mean 59.2 ± 6.66 (SD)	NR	Mean 7.6 ± 7.26 (SD)	6 (3+3): 354 (53%) 7 (3+4): 149 (23%) 7 (4+3): 84 (13%) 8-10: 75 (11%)	NR
Burgess, 2006;[33] Retrospective comparison	Men with localized prostate cancer	Da Vinci	78	NR	NR	NR	NR	NR
		Retropubic radical prostatectomy	16	NR	NR	NR	NR	NR
		Perineal radical prostatectomy	16	NR	NR	NR	NR	NR
Carlsson, 2010;[34] Prospective observational	Men with clinically localized prostate cancer	Da Vinci	1253	Median 62 (range 35-78)	NR	Median 6.3 (range 0.4-50)	T1c: 770 (61.5%) cT2: 435 (34.7%) cT3: 48 (3.8%)	NR

Table A6: Patient Characteristics — Prostatectomy								
First Author, Year; Design	**Inclusion/ Exclusion Criteria**	**Comparison Arms**	**No. of Pts.**	**Age (years)**	**BMI (kg/m^2)**	**Pre-op PSA (ng/mL)**	**Gleason Score**	**Clinical Stage**
		Open radical retropubic prostatectomy	485	Median 63 (47-77)	NR	Median 7.4 (0.1-135)	T1c: 251 (51.8%) cT2: 183 (37.8%) cT3: 50 (10.4%)	NR
Chan, 2008;[35] Prospective observational	Men with clinically localized prostate cancer	Da Vinci	660	Mean 60.0 ± 6.4 (SD)	NR	Mean 6.8 ± 7.9 (SD)	Overall: 6.3 ± 0.7 ≤ 6: 459 (69.6%) 7: 173 (26.2%) 8-10: 28 (4.2%)	T1: 497 (75.3%) T2: 160 (24.2%) T3: 3 (0.5%)
		Open radical prostatectomy	340	Mean 61.2 ± 6.9 (SD)	NR	Mean 8.2 ± 6.7 (SD)	Overall: 6.6 ± 0.9 ≤ 6: 212 (62.4%) 7: 87 (25.6%) 8-10: 41 (12.0%)	T1: 225 (66.2%) T2: 111 (32.6%) T3: 4 (1.2%)
Chino, 2009;[36] Retrospective comparison	NR	Da Vinci	368	Median 59 (range 42-75)	NR	NR	≤ 6: 245 (68%) 3 + 4: 80 (22%) 4 + 3: 25 (7%) ≥ 8: 11 (6%)	T1c: 281 (81%) T2a: 55 (16%) T2b : 5 (1%) T2c: 5 (1%) T3a: 0 T3b: 0
		Open radical prostatectomy (retropubic or perineal)	536	Median 60 (range 40-78)	NR	NR	≤ 6: 302 (61%) 3 + 4: 107 (22%) 4 + 3: 46 (9%) ≥ 8: 38 (8%) (P=0.013)	T1c:353 (73%) T2a: 94 (20%) T2b: 16 (3%) T2c: 12 (2%) T3a: 9 (2%) T3b: 1 (0.2%) (P=0.002)
Coronato, 2009;[37] Retrospective comparison	Men with prostate cancer	Da Vinci	98	Mean 58.9	NR	Mean 6.5	Mean 6.4	T1c: 82 (84%) T2a: 16 (16%)
		Open radical retropubic prostatectomy	57	Mean 59.4	NR	Mean 8.4	Mean 6.3	T1c: 49 (86%) T2a: 8 (14%)
		Open radical perineal prostatectomy	41	Mean 58.9	NR	Mean 6.2	Mean 6.2	T1c: 39 (95%) T2a: 2 (5%)

Table A6: Patient Characteristics — Prostatectomy								
First Author, Year; Design	**Inclusion/ Exclusion Criteria**	**Comparison Arms**	**No. of Pts.**	**Age (years)**	**BMI (kg/m^2)**	**Pre-op PSA (ng/mL)**	**Gleason Score**	**Clinical Stage**
D'Alonzo, 2009;[38] Retrospective comparison	Men with prostate cancer; Excluded patients who underwent additional procedures other than pelvic lymphadenectomies or who received an epidural	Da Vinci	256	Mean 59 ± 6.6 (SD) (n=219)	NR	Mean 6.0 ± 3.5 (SD) (n=219)	Mean 6.2 ± 3.5 (SD) (n=219)	NR
		Radical retropubic prostatectomy	280	Mean 60 ± 6.9 (SD) (n=251)	NR	Mean 7.3 ± 8.1 (SD) (n=251)	Mean 6.4 ± 0.8 (SD) (n=251)	NR
Di Pierro, 2011;[39] Prospective observational	Men with localized prostate cancer	Da Vinci	75	Median 62.8 (IQR 58.4-67.0)	NR	Median 7.72 (IQR 5.6-12.1)	6: 15 (20%) 7: 48 (64%) >8: 12 (16%)	Pathological stage <pT2: 60 (80%) pT3: 14 (18%) pT4: 1 (2%)
		Open radical prostatectomy	75	Median 64.3 (IQR 59.1-68.0)	NR	Median 7.57 (IQR 5.1-10.4)	6: 20 (27%) 7: 38 (15%) >8: 17 (22%)	Pathological stage <pT2: 56 (74%); P=0.5007 pT3: 18 (24%); P=0.708 pT4: 1 (2%)
Doumerc, 2010;[40] Prospective observational	Men with clinically localized prostate cancer. For the first 50 cases of RARP patients with factors that would increase surgical difficulty were excluded (morbid	Da Vinci	212	Mean 61.3 (range 41-76)	NR	Mean 7.1 (range 0.7-41)	6: 73 (34%) 7: 128 (61%) 8: 9 (3.5%) 9: 3 (1.5%)	T1a: 4 (2%) T1b: 2 (1%) T1c: 99 (47%) T2a: 59 (28%) T2b: 16 (7%) T2c: 32 (15%) T3: 0

Table A6: Patient Characteristics — Prostatectomy								
First Author, Year; Design	**Inclusion/ Exclusion Criteria**	**Comparison Arms**	**No. of Pts.**	**Age (years)**	**BMI (kg/m^2)**	**Pre-op PSA (ng/mL)**	**Gleason Score**	**Clinical Stage**
	obesity, previous TURP, history of laparoscopic hernia mesh repair, multiple abdominal operations, high volume tumours)	Open radical retropubic prostatectomy	502	Mean 60.1 (range 40-78)	NR	Mean 8.3 (range 0.9-64)	6: 126 (25%); P=0.01 7: 321 (64%); P=0.41 8: 25 (5%); P=0.81 9: 30 (6%); P=0.01	T1a: 5 (1%); P=0.54 T1b: 5 (1%); P=0.94 T1c: 201 (40%); P=0.11 T2a: 111 (22%); P=0.12 T2b: 70 (14%); P=0.02 T2c: 95 (19%); P=0.26 T3: 15 (3%); P=0.02
Drouin, 2009;[79] Retrospective comparison	Men with localized prostate cancer; exclusion if lymph node involvement found	Da Vinci	71	Mean 60.4 (range 46-70)	Mean 22.6 (range 22-25)	Mean 7.8 (range 3-24)	Mean: 6.2 (range 6-7) <6: 4 (5.6%) 6: 56 (78.9%) 7: 11 (15.5%) >7: 0	T1a-b: 0 T1c: 50 (70.4%) T2a-b: 17 (24%) T2c: 4 (5.6%)
		Open radical prostatectomy	83	Mean 60.5 (range 45-81)	Mean 23.3 (range 22.6-24.8)	Mean 9.2 (range 1.2-60)	Mean: 6.2 (range 4-7) <6: 8 (9.6%) 6: 51 (61.4%) 7: 24 (29%) >7: 0	T1a-b: 2 (2.4%) T1c: 38 (45.8%) T2a-b: 28 (33.7%) T2c: 15 (18.1%)
		Laparoscopic radical prostatectomy	85	Mean 61.8 (range 39-73)	Mean 23 (range 22-25.2)	Mean 8.9 (range 3.4-37)	Mean: 6.2 (range 3-8) <6: 2 (2.4%) 6: 60 (70.6%) 7: 21 (24.6%) >7: 2 (2.4%)	T1a-b: 0 T1c: 55 (64.7%) T2a-b: 22 (25.9%) T2c: 8 (9.4%)
Durand, 2008;[41] Retrospective comparison	Men with localized prostate cancer	Da Vinci	34	Mean 62.2 (range 46.5-70.1)	NR	Mean 6.97 (range 3-19)	3+3:24 (70.6%) 3+4: 6 (17.7%) 4+3: 3 (8.8%) 4+4: 1 (2.9%)	NR
		Retropubic total prostatectomy	29	Mean 61.1 (range 51-73)	NR	Mean 7.03 (range 3.1-17.7)	3+3:21 (72.4%) 3+4: 5 (17.2%) 4+3: 3 (10.4%)	NR

Table A6: Patient Characteristics — Prostatectomy								
First Author, Year; Design	**Inclusion/ Exclusion Criteria**	**Comparison Arms**	**No. of Pts.**	**Age (years)**	**BMI (kg/m^2)**	**Pre-op PSA (ng/mL)**	**Gleason Score**	**Clinical Stage**
		Transperitoneal laparoscopic prostatectomy	23	Mean 66.1 (range 43.2-77.5)	NR	Mean 9.53 (range 3.2-37)	3+3:12 (52.1) 3+4: 7 (30.4%) 4+3: 2 (8.7%) 4+4: 1 (4.4%) 5+4: 1 (4.4%)	NR
Farnham, 2006;[42] Prospective observational	Men with clinically localized prostate cancer	Da Vinci	176	Mean 59 ± 7 (SD)	NR	Mean 6.5 ± 4.7 (SD)	Mean 6.2 ± 0.8 (SD)	NR
		Radical retropubic prostatectomy	103	Mean 60 ± 7.8 (SD) (P=0.44)	NR	Mean 8.3 ± 8.9 (SD) (P=0.02)	Mean 6.4 ± 1.1 SD) (P=0.24)	NR
Ficarra, 2009;[43] Prospective observational	Men with clinically localized prostate cancer	Da Vinci	103	Median 61 (IQR 57-67) (P=<0.001)	Median 26 (IQR 24-28)	Median 6.4 (IQR 4.6-9)	6: 71 (73%) 7: 18 (19%) 8-10: 8 (8%)	T1c:77 (75%) T2a-b: 22 (21%) T2c: 4 (4%)
		Retropubic radical prostatectomy	105	Median 65 (IQR 61-69)	Median 26 (IQR 24-28) (P=0.22)	Median 6 (IQR 5-10) (P=0.32)	6: 67 (64%) 7: 29 (28%) 8-10: 8 (8%)	T1c: 66 (63%) T2a-b: 32 (30%) T2c: 7 (7%)
Fracalanza, 2008;[44] Prospective observational	Men with clinically localized prostate cancer	Da Vinci	35	Median 62 (IQR 56-68)	Mean 25.5 ± 2.7 (SD)	Median 6.2 (IQR 4.2-10.2)	4: 1 (3%) 5: 2 (6%) 6: 11 (31%) 7: 13 (37%) 8: 7 (20%) 9: 1 (3%)	T2a: 4 (11%) T2c: 19 (54%) T3a: 11 (31%) T3b: 1 (3%)
		Retropubic radical prostatectomy	26	Median 68.5 (IQR 59-71) (P=<0.009)	Mean 26.4 ± 3.7 (SD) (P=0.2)	Median 6.2 (IQR 4.5-9.1) (P=0.7)	4: 0 5: 2 (8%) 6: 4 (15%) 7: 16 (62%) 8: 3 (12%) 9: 1 (4%) (P=0.1)	T2a: 3 (12%) T2c: 8 (31%) T3a: 11 (42%) T3b: 4 (15%)
Hakimi, 2009;[69] Retrospective comparison	NR	Da Vinci	75	Mean 59.8 (range 42-71)	NR	Mean 8.4	≤ 6: 34 (45.3%) 7: 40 (53.3%) ≥ 8: 1 (1.3%)	pT2: 64 (85.3%) pT3: 11 (14.7%)

Table A6: Patient Characteristics — Prostatectomy								
First Author, Year; Design	**Inclusion/ Exclusion Criteria**	**Comparison Arms**	**No. of Pts.**	**Age (years)**	**BMI (kg/m^2)**	**Pre-op PSA (ng/mL)**	**Gleason Score**	**Clinical Stage**
		Laparoscopic radical prostatectomy	75	Mean 59.6 (range 43-72) (P=0.88)	NR	Mean 7.5 (P=0.217)	≤ 6: 44 (58.7%) (P=0.14) 7: 28 (37.3%) (P=0.07) ≥ 8: 3 (4%) (P=0.62)	pT2: 71(94.7%) (P=0.099) pT3: 4 (5.3%) (P=0.099)
Ham, 2008;[45] Prospective observational	Men with prostate cancer without distant metastases	Da Vinci	223	Mean 67.1 ± 8.0 (SD)	Mean 23.6 ± 2.2 (SD)	Mean 20.2 ± 20.2 (SD)	≤6: 83 (37.2%) 7: 89 (39.9%) ≥8: 51 (22.9%)	Pathological stage pT0: 1 (<1%) pT2: 140 (62.8%) pT3: 72 (32.3%) pT4: 10 (4.5%)
		Open radical prostatectomy	199	Mean 66.1 ± 6.2 (SD)	Mean 23.7 ± 1.8 (SD)	Mean 40.7 ± 129.5 (SD)	≤6: 87 (43.7%) 7: 52 (31.2%) ≥8: 50 (25.1%)	Pathological stage pT0: 8 (4%) pT2: 91 (45.7%) pT3: 81 (40.7%) pT4: 19 (9.6%)
Hohwü, 2009;[46] Retrospective comparison	NR	Da Vinci	127	Mean 57.9 (range 43-64)	Mean 25.9 (range 20.1-34.8)	Mean 7.7 (range 0.8-38)	2-6: 81 (64.8%) 7-10: 44 (35.2%)	T1: 77 (61.1%) T2+ T3: 49 (38.9%)
		Open retropubic prostatectomy	147	Mean 58 (range 42-63)	Mean 26.9 (range 19.8-44.9)	Mean 11.7 (range 0.4-60)	2-6: 98 (67.6%) 7-10: 47 (32.4%); Tumour size NR	T1: 85 (57.8%) T2+ T3: 62 (42.8%)
Hu, 2006;[70] Retrospective comparison	NR	Da Vinci	322	Mean 62.1 (range 41-84)	Mean 27.5 (range 17.8-51.5)	NR	1-5: 5 (1.6%) 6-7: 289 (93.5%) 8-10: 15 (4.9%) Median: 6 (range 4-9)	T1a: 1 (0.3%) T1b: 0 T1c: 231 (74.5%) T2a: 59 (19.0%) T2b: 11 (3.5%) T2c: 7 (2.3%) T3a: 1 (0.3%) T3b: 0

Table A6: Patient Characteristics — Prostatectomy								
First Author, Year; Design	Inclusion/ Exclusion Criteria	Comparison Arms	No. of Pts.	Age (years)	BMI (kg/m^2)	Pre-op PSA (ng/mL)	Gleason Score	Clinical Stage
		Laparoscopic radical prostatectomy	358	Mean 63.7 (range 40-83)	Mean 27.4 (range 17.9-43.8)	NR	1-5: 9 (2.5%) 6-7: 322 (90.2%) 8-10: 26 (7.3%) Median: 6 (range 4-10)	T1a: 6 (1.7%) T1b: 2 (0.6%) T1c: 261 (72.9%) T2a: 72 (20.2%) T2b: 4 (1.1%) T2c:10 (2.8%) T3a: 1 (0.3%) T3b: 2 (0.6%)
Joseph, 2005;[71] Retrospective comparison	Men with localized prostate cancer	Da Vinci	50	Mean 59.6 (95% CI 1.6)	NR	Mean 7.3 (95% CI 1.2)	Mean 6 (95% CI 0.15)	T1c: 43 (86%) T2a: 6 (12%) T2b: 1 (2%)
		Laparoscopic radical prostatectomy	50	Mean 61.8 (95% CI 1.6) (P=0.06)	NR	Mean 6.0 (95% CI 0.83) (P=0.06)	Mean 6 (95% CI 0.14) (P=0.13)	T1c: 34 (68%) T2a: 14 (28%) T2b: 2 (4%)
Kordan, 2010;[47]	Mean with localized prostate cancer	Da Vinci	830	Mean 60.5 ± 7.2 (SD)	Mean 28.2 ± 4.2 (SD)	Median 5.5 (IQR 4.4-7.3)	≤ 6: 578 (69.8%) 7: 211 (25.5%) 8-10: 39 (4.7%)	≥ cT2: 204 (24.8%)
		Open radical prostatectomy	414	Mean 61.5 ± 7.5 (SD)	Mean 28.0 ± 4.6 (SD)	Median 6.0 (IQR 4.6-9.1)	≤ 6: 261 (63.0%) 7: 104 (25.1%) 8-10: 49 (11.8%)	≥ cT2: 128 (31.2%)
Krambeck, 2009;[48] Prospective observational (robotic) compared with historical	Men with clinically localized prostate cancer	Da Vinci	294	Mean 61 (range 38-76)	NR	Mean 4.9 (range 0.5-33.5)	<6: 2 (0.7%) 6: 212 (72.1%) 7: 70 (23.8%) ≥8: 10 (3.4%)	T1c : 214 (72.8%) T2a: 75 (25.5%) T2b : 4 (1.4%) T3 or T4 : 1 (0.3%)

Table A6: Patient Characteristics — Prostatectomy								
First Author, Year; Design	**Inclusion/ Exclusion Criteria**	**Comparison Arms**	**No. of Pts.**	**Age (years)**	**BMI (kg/m^2)**	**Pre-op PSA (ng/mL)**	**Gleason Score**	**Clinical Stage**
cohort		Radical retropubic prostatectomy	588	Mean 61 (range 41-77)	NR	Mean 5.0 (range 0.6-39.7)	<6: 0 6: 441 (75.0%) 7: 133 (22.6%) ≥8: 14 (2.3%)	T1a or T1b : 4 (0.7%) T1c : 418 (71.1%) T2a : 130 (22.1%) T2b : 28 (4.8%) T3 or T4 : 8 (1.4%)
Laurila, 2009;[49] Retrospective comparison	NR	Da Vinci	94	Mean 59.8 (range 47-71)	NR	Mean 6.7 (range 0.3-42)	2-4: 0 5-7: 92 8-10: 2	T1c: 91 (96.8%) T2: 3 (3.2%)
		Open radical retropubic prostatectomy	98	Mean 58.8 (range 37-74) (P=0.6)	NR	Mean 5.9 (range 1.3-13) (P=0.03) Note: this statistically significant difference was corrected in risk-stratified analysis	2-4: 0 5-7: 88 8-10: 10 (P=0.03)	T1c: 85 (86.7%) T2: 13 (13.3%) (P=0.02)
Lo, 2010;[50] Retrospective comparison	NR	Da Vinci	20	Mean 64 (range 52-75)	NR	Mean 14.2 ± 11.8 (SD)	Median 7 (range 6-9)	Median T2c (range T1a-T3a)
		Open radical prostatectomy	20	Mean 66 (range 47-76)	NR	Mean 14.5 ± 14.3 (SD)	Median 7 (range 6-10)	Median T2c (range T1c-T3b)

Table A6: Patient Characteristics — Prostatectomy								
First Author, Year; Design	**Inclusion/ Exclusion Criteria**	**Comparison Arms**	**No. of Pts.**	**Age (years)**	**BMI (kg/m^2)**	**Pre-op PSA (ng/mL)**	**Gleason Score**	**Clinical Stage**
Madeb, 2007 ;[51] Retrospective comparison	Men with clinically localized prostate cancer, including pts with previous abdominal surgery including preperitoneal hernia repair with mesh	Da Vinci	100	Mean 62.6	NR	Mean 7.33	NR	NR
		Open radical prostatectomy	100	Mean 64.9	NR	Mean 8.51	NR	NR
Menon, 2002;[72] Prospective observational	Men with prostate cancer	Da Vinci	40	Mean 60.7 (1.2 SE)	Mean 27.7 (0.5 SE)	Mean 5.7 (0.5 SE)	NR	T1c: 28 (70%) T2a: 5 (12.5) T2b: 7 (17.5) T2c:0
		Laparoscopic radical prostatectomy	40	Mean 62.8 (1.1 SE) (P=0.21)	Mean 27.7 (0.5 SE)	Mean 6.9 (0.7 SE?) (P=0.18)	NR	T1c: 26 (65) T2a: 3 (7.5) T2b: 9 (22.5) T2c: 2 (5) (P=0.82)
Menon, 2002;[52] Prospective observational	Men with clinically localized prostate cancer, medical fit for surgery; weight < 250 lb., waist size < 45 in., BMI < 35 kg/m^2	Da Vinci	30	Mean 62 (range 51-71)	Mean 30	Mean 9.94 (range 2-19)	Mean: 6.3 ± 1.0 5: 1 (3.3%) 6: 19 (63.3%) 7: 7 (23.3%) 8: 3 (9.9%)	T1c: 22 (83%) T2a: 2 (6.6%) T2b: 3 (9.9%) T2c: 3 (9.9%)
		Open radical retropubic prostatectomy	30	Mean 64 (range 59-70)	Mean 30	Mean 8.40 (range 1.5-16)	Mean: 6.3 ± 0.8 5: 2 (6.6%) 6: 17 (56.6%) 7: 9 (30%) 8: 2 (6.6%)	T1c: 20 (77%) T2a: 3 (9.9%) T2b: 3 (9.9%) T2c: 4 (13.2%)
Miller, 2007;[53] Prospective observational	Men with clinically localized (cT1-T2) prostate cancer	Da Vinci	42	Mean 61.1	NR	NR	NR	NR
		Open radical prostatectomy	120	Mean 60.6 (P=0.66)	NR	NR	NR	NR

Table A6: Patient Characteristics — Prostatectomy								
First Author, Year; Design	Inclusion/ Exclusion Criteria	Comparison Arms	No. of Pts.	Age (years)	BMI (kg/m^2)	Pre-op PSA (ng/mL)	Gleason Score	Clinical Stage
Nadler, 2010;[54] Prospective observational (robotic) compared with historical cohort	Men with clinically localized prostate cancer	Da Vinci	50	Mean 59.7 (range 44-77)	Mean 28.6 (range 22.3-42.0)	Mean 6.5 (range 1.5-18.8)	Mean 6.42 (range 6-9)	Pathological stage pT2: 43 (86%) pT3: 7 (14%)
		Open radical retropubic prostatectomy	50	Mean 60.0 (range 40-75)	Mean 28.2 (range 21.0-42.6)	Mean 8.5 (range 1.9-95.6)	Mean 6.66 (range 6-10)	Pathological stage pT2: 33 (66%) pT3: 17 (34%)
Nelson, 2007;[55] Prospective cohort	Men with prostate cancer requiring prostatectomy	Da Vinci	629	Mean 59.3	NR	Mean 6.7	Mean 6.2	NR
		Radical retropubic prostatectomy	374	Mean 59.9	NR	Mean 8.4	Mean 6.3	NR
O'Malley, 2006;[56] Prospective observational	NR	Da Vinci	102	Mean 60.7 (range 47-73)NR	NR	Mean 7.8 (1.3-21.2)	Median 7 (6-8)	Pathological stage pT2a: 19 pT2b: 70 pT3a: 13 pT3b: 0
		Open radical retropubic prostatectomy	102	Mean 59.9 (range 45-72)		Mean 9.9 (0.9-37.6)	Median 6 (4-9)	Pathological stage pT2a:10 pT2b: 57 pT3a: 30 pT3b: 5
Ou, 2009;[57] Retrospective comparison	Men with prostate cancer	Da Vinci	30	Mean 67.3 ± 6.2 (SD)	Mean 24.2 ± 3.2 (SD)	Mean 16.45 ± 18.80 (SD)	Mean 6.13 ± 0.9	T1:15 (50%) T2:15 (50%) T3: 0
		Radical retropubic prostatectomy	30	Mean 70.0 ± 6.1 (SD) (P=<0.05)	Mean 24.1 ± 3.3 (SD)	Mean 15.89 ± 14.15 (SD)	Mean 6.22 ± 1.62	T1: 9 (30%) T2: 19 (63%) T3: 2 (7%)
Ploussard, 2009;[73] Prospective observational	NR	Da Vinci	83	Mean 62.8 ± 6.0 (SD)	Mean 26.6 ± 4.0 (SD)	Mean 9.2 ± 9.8 (SD)	<6: 69.1% 7: 30.9% >7: 0	T1c: 89.1%
		Laparoscopic radical prostatectomy	205	Mean 62.9 ± 7.4(SD) (P=0.95)	Mean 26.3 ± 3.6 (SD) (P=0.52)	Mean 8.2 ± 5.3 (SD) (P=0.40)	<6: 61.9% (P=0.57) 7: 34.0% >7: 4.1%	T1c: 78.1% (P=0.11)

Table A6: Patient Characteristics — Prostatectomy								
First Author, Year; Design	**Inclusion/ Exclusion Criteria**	**Comparison Arms**	**No. of Pts.**	**Age (years)**	**BMI (kg/m^2)**	**Pre-op PSA (ng/mL)**	**Gleason Score**	**Clinical Stage**
Prewitt, 2008;[58] Retrospective comparison	NR	Da Vinci	61	NR	NR	NR	NR	NR
		Open radical prostatectomy	100					
Rocco, 2009;[59] Prospective observational (robotic) compared with historical cohort	Men with prostate cancer	Da Vinci	120	Median 63 (range 47-76)	NR	Median 6.9 (range 0.4-23.0)	Median 6 (range 4-9)	T1c: 82 (69%) cT2a: 36 (31%) Note: cT missing for 2 pts
		Open retropubic prostatectomy	240	Median 63 (range 46-77) (P=0.358)	NR	Median 6.7 (range 0.7-22.0) (P=0.858)	Median 6 (range 4-10) (P=0.321)	T1c: 145 (61%) (P=0.11) cT2a: 93 (39%) Note: cT missing for 2 pts
Rozet, 2007[74] Retrospective comparison	Men with localized prostate cancer	Da Vinci	133	Mean 62.0 (range 49-76)	Mean 24.8 (range 18.8-35.5)	Mean 7.6 (range 0.9-38.0)	≤ 6: 101 (76%) 7: 29 (21.8%) >7: 3 (2.2%) Mean: 6.3 (4.0-9.0)	T1b: 0 T1c: 76 (57.1%) T2a: 51 (38.3%) T2b: 6 (4.5%) T3a: 0
		Laparoscopic radical prostatectomy	133	Mean 62.5 (range 47-74) (P=0.46)	Mean 25.3 (range 19.3-32.7) (P=0.31)	Mean 7.8 (range 3.2-19.0) (P=0.81)	≤ 6: 93 (70%) 7: 37 (27.8%) >7: 3 (2.2%) Mean: 6.3 (4.0-9.0) (P=0.32)	T1b: 1 (0.8%) T1c: 90 (67.7%) T2a: 39 (29.3%) T2b: 2 (1.5%) T3a: 1 (0.8%)
Schroeck, 2008;[60] Retrospective comparison	Men with prostate cancer	Da Vinci	362	Median 59.2 (IQR 54.5-63.8)	Median 27.8 (IQR 25.7-29.9)	Median 5.4 (IQR 4.1-7.1)	2-6: 254 (72.2%) 7: 89 (25.3%) 8-10: 9 (2.6%)	T1: 281 (83.1%) T2: 57 (16.9%) T3: 0
		Radical retropubic prostatectomy	435	Median 60.3 (IQR 55.3-64.7)	Median 27.7 (IQR 25.5-30.4)	Median 5.3 (IQR 4.1-7.2)	2-6: 241 (58.8%) 7: 127 (31.0%) 8-10: 42 (10.2%) (P=<0.001)	T1: 296 (72.4%) T2: 101 (24.7%) T3: 12 (2.9%) (P=<0.001)
Smith, 2007;[61] Retrospective	Men with prostate cancer who had	Da Vinci	200	Mean 60.3 (range	Mean 61.1 (range	Mean 6.4 (range 0.5-58)	≤ 6: 140/200 (70%) 7: 52 (26%)	T1: 151/200 (75.5%) T2: 48 (24%)

Table A6: Patient Characteristics — Prostatectomy								
First Author, Year; Design	**Inclusion/ Exclusion Criteria**	**Comparison Arms**	**No. of Pts.**	**Age (years)**	**BMI (kg/m^2)**	**Pre-op PSA (ng/mL)**	**Gleason Score**	**Clinical Stage**
comparison	undergone prostatectomy			39-78)	43-81) (P=0.275)		8-10: 8 (4%) Mean total: 6.3 (range 3-10)	T3: 1 (0.5%)
		Open retropubic radical prostatectomy	200	Mean 61.1 (range 43-81) (P=0.275)	Mean 27.8 (range 16.3-52.6) (P=0.129)	Mean 8.3 (range 0.52-51.7) (P=0.002)	≤ 6: 121/200 (60.5%) 7: 59 (29.5%) 8-10: 20 (10%) Mean total: 6.6 (range 4-10) (P=0.005)	T1: 129/200 (64.5%) (P=0.016) T2: 69 (34.5%) (P=0.02) T3: 1 (0.5%) (P=1.0)
Srinualnad, 2008;[75] Prospective robotic observational compared with historical cohort	Men with clinically localized prostate cancer (adenocarcinoma of the prostate)	Da Vinci	34	Mean 67.1 ± 6.5 (SD)	NR	Mean 14.4 ± 17.8 (SD)	NR	NR
		Laparoscopic radical prostatectomy	34	Mean 68.6 ± 7.7 (SD)	NR	Mean 54.7 ± 29.9 (SD)	NR	NR
Tewari, 2003;[62] Prospective observational	Men with clinically localized prostate cancer; 10-year life expectancy; Gleason score ≥ 6	Da Vinci	200	Mean 59.9 (SD 40-72)	Mean 27.7 (SD 19-38)	Mean 6.4 (SD 0.6-41)	Mean: 6.5 5: 0 6: 67% 7: 28% 8: 4% 9-10: 2%	T1a: 0.5% T1c: 49% T2a: 10% T2b: 39% T3a: 1.5%
		Radical retropubic prostatectomy	100	Mean 63.1 (SD 42.8-72) (P=NS)	Mean 27.6 (SD 17-41) (P=NS)	Mean 7.3 (SD 1.9-35) (P=NS)	Mean: 6.6 5: 3% 6: 49% 7: 35% 8: 10% 9-10: 3% (P=NS)	T1a: 0 T1c: 59% T2a: 10% T2b: 35% T3a: 4% (P=NS)
Trabulsi, 2008;[76] Retrospective comparison	Men with prostate cancer electing radical prostatectomy	Da Vinci (using transperitoneal technique)	50	Mean 57.7 (range 37-70)	Mean 28.4 (range 20.4-36.6)	Mean 5.5 (range 1.1-21.1)	≤ 6: 36 (72%) 3+4: 8 (16%) 4+3: 4 (8%) ≥ 8: 2 (4%)	cT1c: 41 (82%) cT2a: 9 (18%)

Table A6: Patient Characteristics — Prostatectomy								
First Author, Year; Design	**Inclusion/ Exclusion Criteria**	**Comparison Arms**	**No. of Pts.**	**Age (years)**	**BMI (kg/m^2)**	**Pre-op PSA (ng/mL)**	**Gleason Score**	**Clinical Stage**
		Laparoscopic transperitoneal radical prostatectomy	190	Mean 58.6 (range 43-74) (P=0.441)	Mean 26.8 (range 18.8-51.8) (P=0.036)	Mean 6.5 (range 0.4-46) (P=0.103)	≤ 6: 136 (72%) 3+4: 31 (16%) 4+3: 6 (3%) ≥ 8: 3 (2%)	cT1c: 145 (76%) cT2a: 40 (21%)
Trabulsi, 2010;[77] Retrospective comparison	NR	Da Vinci	205	Mean 59.9 (range 42-76)	NR	Mean 6.4	≤ 6a: 126 (62%) 7: 58(28%) ≥ 8: 21 (10%)	NR
		Laparoscopic radical prostatectomy	45	Mean 58.1 (range 43-74) (P=NS)	NR	Mean 6.2 (P=NS)	≤ 6a: 34 (76%) 7: 11 (24%) ≥ 8: 0	NR
Truesdale, 2010;[63] Retrospective comparison	Men with clinically localized prostate cancer	Da Vinci	99	Mean 59.2 ± 7.1 (SD)	Mean 24.6 ± 8.3 (SD)	Mean 7.04 ± 7.5 (SD)	≤ 6: 28 (28.3%) 7: 34 (34.3%) ≥ 8: 37 (37.4%)	NR
		Open radical prostatectomy	217	Mean 61.7 ± 6.8 (SD)	Mean 23.1 ± 9.1 (SD)	Mean 8.35 ± 7.62 (SD)	≤ 6: 63 (29.0%) 7: 95 (43.8%) ≥ 8: 59 (27.2%)	NR
Webster, 2005;[64] Prospective observational	NR	Da Vinci	159	Mean 59.42 ± 7.02 (SD)	NR	Mean 6.31 ± 4.80 (SD)	NR	NR
		Retropubic radical prostatectomy	154	Mean 60.06 ± 7.78 (SD) (P=0.443)	NR	Mean 8.62 ± 8.64 (SD) (P=0.004)	NR	NR
White, 2009;[65] Retrospective comparison	Men with prostate cancer requiring prostatectomy	Da Vinci	50	Mean 62	NR	Mean 4.63	6: 39 (78%) 7: 10 (20%) 8: 1 (2%)	T1: 40 (80%) T2: 10 (20%)

Table A6: Patient Characteristics — Prostatectomy								
First Author, Year; Design	**Inclusion/ Exclusion Criteria**	**Comparison Arms**	**No. of Pts.**	**Age (years)**	**BMI (kg/m^2)**	**Pre-op PSA (ng/mL)**	**Gleason Score**	**Clinical Stage**
		Radical retropubic prostatectomy	50	Mean 64.7 (P=0.08)	NR	Mean 5.04 (P=0.40)	6: 40 (80%) (P=0.34) 7: 9 (18%) (P=0.37) 8: 1 (2%)	T1: 38 (76%) (P=0.34) T2: 12 (24%) (P=0.37)
Williams, 2010;[66] Retrospective comparison	Men with clinically localized prostate cancer	Da Vinci	604	Median 59.0 (IQR 54-63)	NR	Median 4.8 (IQR 3.9-6.2)	≤ 6: 381 (63%) 7: 195 (32%) 8-10: 28 (5%)	NR
		Open radical retropubic prostatectomy	346	Median 59.5 (IQR 54.5-64)	NR	Median 4.8 (IQR 3.8-6.0)	≤ 6: 233 (67%) 7: 94 (27%) 8-10: 19 (5%)	NR
Wood, 2007;[67] Prospective observational	Men with localized prostate cancer	Da Vinci	117	Mean 60.2	NR	Mean 6.5	5-6: 27 (23%) 7: 84 (73%) 8-10: 4 (4%)	NR
		Conventional prostatectomy	89	Mean 59.2	NR		5-6: 27 (30%) 7: 57 (64%) 8-10: 5 (6%)	NR
Zorn, 2009;[68] Prospective robotic surgery cohort compared with retrospective open surgery cohort	Men with localized prostate cancer requiring radical prostatectomy with pelvic lymphadenectomy	Da Vinci	296	Mean 61.0 (range 44-85)	NR	Mean 9.0 (range 0.89-52)	6: 52 (17%) 7: 182 (62%) 8-10: 62 (21%)	T1c: 180 (61%) T2a-cT2b: 112 (38%) T3: 4 (1%)
		Open radical prostatectomy	471	NR	NR	NR	NR	NR

BMI=body mass index; CI=confidence intervals; IQR=intraquartile range; No.=number; NR=not reported; NS=not significant; PSA=prostate specific antigen; pts=patients; SD=standard deviation; SE=standard error

Table A7: Patient Characteristics — Hysterectomy							
First Author, Year; Design	**Inclusion/ Exclusion Criteria**	**Comparison Arms**	**No. of Pts.**	**Age (years)**	**BMI (kg/m^2)**	**Tumour Size or Uterine Weight**	**Clinical Stage (FIGO)**
Bell, 2008;[102] Retrospective comparison	Women with endometrial cancer	Da Vinci	40	Mean 63 ± 1.01 (SD) (vs laparotomy P=0.0005; vs laparoscopy P=0.03)	Mean 33.0 ± 8.5 (SD) (vs laparotomy P=0.54; vs laparoscopy P=0.59)	Uterine weight (g): Mean 155.6 ± 134.8 (SD) (vs laparotomy P=0.41; vs laparoscopy P=0.87)	NR
		Open hysterectomy	40	Mean 72.3 ± 12.5 (SD)	Mean 31.8 ± 7.7 (SD)	Uterine weight (g): Mean 138.5 ± 75.5 (SD)	NR
		Laparoscopic hysterectomy	30	Mean 68.4 ± 11.9 (SD)	Mean 31.9 ± 9.8 (SD)	Uterine weight (g): Mean 135.9 ± 72.8	NR
Boggess, 2008;[103] Prospective observational (robotic) compared with historical cohort	Women with endometrial cancer	Da Vinci	103	Mean 61.9 ± 10.6 (SD) (vs laparoscopy P=0.06; vs laparotomy P=0.95)	Mean 32.9 ± 7.6 (SD) (vs laparoscopy P=0.17; vs laparotomy P=0.0008)	NR	IA: 38 (36.9%) IB: 41 (39.8%) IC: 10 (9.7%) IIA: 1 (1%) IIB: 2 (1.9%) IIIA/IIIB/IIIC: 10 (9.7%) IVA/IVB: 0 Unstaged: 1 (1%)
		Open hysterectomy	138	Mean 64.0 ± 12.8 (SD)	Mean 34.7 ± 9.2 (SD)	NR	IA: 37 (26.8%) IB: 49 (35.5%) IC: 13 (9.4%) IIA: 5 (3.6%) IIB: 8 (5.8%) IIIA/IIIB/IIIC: 17 (12.3%) IVA/IVB: 3 (2.2%) Unstaged: 6 (4.4%)
		Laparoscopic hysterectomy	81	Mean 62.0 ± 10.8 (SD)	Mean 29.0 ± 6.5 (SD)	NR	IA: 23 (28.4%) IB: 28 (34.6%) IC: 11 (13.6%) IIA: 4 (4.9%) IIB: 0 IIIA/IIIB/IIIC: 14 (17.3%) IVA/IVB: 1 (1.2%) Unstaged:0

Table A7: Patient Characteristics — Hysterectomy							
First Author, Year; Design	**Inclusion/ Exclusion Criteria**	**Comparison Arms**	**No. of Pts.**	**Age (years)**	**BMI (kg/m^2)**	**Tumour Size or Uterine Weight**	**Clinical Stage (FIGO)**
Boggess, 2008;[80] Prospective observational (robotic) compared with historical cohort	Women with early-stage cervical cancer	Da Vinci	51	Mean 47.4 ± 12.9 (SD)	Mean 28.6 ± 7.2 (SD)	Uterine weight (g): Mean 137.8 ± 56.5 (SD)	IA1: 1 (2.0%) IA2: 5 (9.8%) IB1: 37 (72.5%) IB2: 3 (5.9%) IIA: 1 (2.0%) Other: 4 (7.8%)
		Open radical hysterectomy	49	Mean 41.9 ± 11.2 (SD) (P=0.029)	Mean 26.1 ± 5.1 (SD) (P=0.08)	Uterine weight (g): Mean 132.6 ± 55.5 (SD) (P=0.64)	IA1: 0 IA2: 4 (8.2%) IB1: 40 (81.6%) IB2: 4 (8.2%) IIA: 1 (2%) (P=0.32)
Cantrell, 2010;[81] Retrospective comparison	Women with early stage cervical cancer	Da Vinci	63	Median 43 (range 17-75)	Median 28 (range 18-49)	NR	IA1: 4 (6%) IA2: 5 (8%) IB1: 49 (79%) IB2: 3 (5%) IIA: 1 (1%) IIB: 1 (1%)
		Open Piver type III radical hysterectomy	64	Median 41.5 (range 20-72)	Median 25 (range 19-37)	NR	IA1: 0 IA2: 5 (8%) IB1: 51 (80%) IB2: 7 (11%) IIA: 1 (1%) IIB: 0
Cardenas-Goicoechea, 2010[94] Retrospective comparison	Women with endometrial cancer	Da Vinci	102	Mean 62 ± 8.7 (SD)	Mean 32.3 ± 8.1 (SD)	Uterine weight (g) Mean 148 ± 111 (SD)	IA: 31 (30.4%) IB: 37 (36.3%) IC: 14 (13.7%) IIA: 1 (1.0%) IIB: 2 (2.0%) IIIA: 8 (7.8%) IIIC: 8 (7.8%) IVA: 1 (1.0%)
		Laparoscopic hysterectomy	173	Mean 59.6 ± 9.8 (SD)	Mean 32.7 ± 9.5 (SD)	Uterine weight (g) Mean 139 ± 89.8 (SD)	IA: 65 (37.6%) IB: 63 (36.4%) IC: 24 (13.9%) IIA: 3 (1.7%) IIB: 6 (3.5%) IIIA: 6 (3.5%) IIIC: 5 (2.9%) IVA: 1 (0.6%)

Table A7: Patient Characteristics — Hysterectomy							
First Author, Year; Design	**Inclusion/ Exclusion Criteria**	**Comparison Arms**	**No. of Pts.**	**Age (years)**	**BMI (kg/m^2)**	**Tumour Size or Uterine Weight**	**Clinical Stage (FIGO)**
DeNardis, 2008;[82] Retrospective comparison	Women with endometrial cancer	Da Vinci (hysterectomy with pelvic lymphadenectomy)	56	Mean 58.9 ± 10.3 (SD)	Mean 28.5 ± 6.4 (SD)	NR	0: 0 IA: 16 (28.5%) IB: 25 (44.5%) IC: 5 (9%) IIA: 2 (3.5%) IIB: 2 (3.5%) IIIA: 3 (5.5%) IIIB: 0 IIIC: 3 (5.5%) IV: 0
		Open total hysterectomy with pelvic lymphadenectomy	106	Mean 62.5 ± 10.8 (SD) (P=0.05)	Mean 34.0 ± 9.3 (SD) (P=0.0001)	NR	0: 1 (1%) IA: 21 (20%) IB: 42 (39.5%) IC: 10 (9.5%) IIA: 3 (3%) IIB: 5 (4.5%) IIIA: 12 (11%) IIIB: 1 (1%) IIIC: 10 (9.5%) IV: 1 (1%)
Estape, 2009;[104] Prospective observational (robotic) compared with historical cohort	Women with cervical cancer	Da Vinci	32	Mean 55.0 ± 12.7 (SD) (vs laparoscopy P=NS; vs laparotomy P=0.004)	Mean 29.7 ± 3.2 (SD) (P=NS)	Depth of invasion (mm): Mean 3.1 ± 2.4 (SD) (P=NS)	1A2=0 1B1=29 (90.6%) 1B2=3 (9.4%) (P=NS)
		Open hysterectomy	14	Mean 42.0 ± 12.0 (SD)	Mean 29.5 ± 6.4 (SD)	Depth of invasion (mm): Mean 4.6 ± 3.6 (SD)	1A2=0 1B1=13 (92.9%) 1B2=1 (7.1%)
		Laparoscopic hysterectomy	17	Mean 52.8 ± 14.2 (SD)	Mean 28.1 ± 4.8 (SD)	Depth of invasion (mm): Mean 3.5 ± 2.7 (SD)	1A2=2 (11.8%) 1B1=14 (82.4%) 1B2=1 (5.9%)
Feuer, 2010;[83] Prospective observational (robotic) compared with historical cohort	Women with early stage cervical cancer	Da Vinci	32	Mean 43.3 ± 12.0 (SD)	Mean 26.3 ± 5.6 (SD)	Uterine weight (g): Mean 124.8 ± 44.7 (SD)	CIN III: 9.4 IA1: 6.2 IA2: 9.4 IB: 56.2 IB2: 3.1 IIA: 3.1
		Open radical hysterectomy using a modified unilateral Wertheim procedure	20	Mean 39.0 ± 6.46 (SD)	Mean 27.0 ± 5.2 (SD)	Uterine weight (g): Mean 199.2 ± 209.7 (SD)	CIN III: 5 IA1: 20 IA2: 5 IB: 60 IB2: 10 IIA: 0

Table A7: Patient Characteristics — Hysterectomy							
First Author, Year; Design	**Inclusion/ Exclusion Criteria**	**Comparison Arms**	**No. of Pts.**	**Age (years)**	**BMI (kg/m^2)**	**Tumour Size or Uterine Weight**	**Clinical Stage (FIGO)**
Gehrig, 2008;[95] Retrospective comparison	Obese and morbidly obese women with endometrial cancer (Obese defined as BMI 30-39.9; morbidly obese as BMI ≥ 40)	Da Vinci	49	Mean 61.3 (range 42-90)	Mean 37.5 (range 30-53)	NR	I-II: 44 (89%) III-IV: 5 (11%)
		Laparoscopic hysterectomy	32	Mean 61.2 (range 32-80) (P=NS)	Mean 35 (range 30-55) (P=NS)	NR	I-II: 26 (81%) (P=NS) III-IV: 6 (19%) (P=NS)
Geisler, 2010[84] Retrospective comparison	Women with early cervical cancer	Da Vinci (type III radical hysterectomy and bilateral pelvic lymphadenectomy)	15	Mean 49	Mean 34	NR	NR
		Open type III radical hysterectomy	30	Mean 51	Mean 32	NR	NR
Gocmen, 2010;[85] Prospective observational	Women with endometrial cancer	Da Vinci (5-trocar transperitoneal approach; hysterectomy combined with pelvic lymph node dissection, or pelvic-paraaortic lymph node dissection)	10	Mean 55.7 (range 37-66)	Mean 32.7 (range 24.5-40.3)	NR	FIGO grade: I-II: 8 (80%) III-IV: 2 (20%)
		Laparotomy; hysterectomy combined with pelvic lymph node dissection, or pelvic-paraaortic lymph node dissection	12	Mean 56.4 (range 47-75)	Mean 30.3 (range 25.9-35.8)	NR	FIGO grade: I-II: 9 (75%) II-IV: 3 (25%)

Table A7: Patient Characteristics — Hysterectomy							
First Author, Year; Design	**Inclusion/ Exclusion Criteria**	**Comparison Arms**	**No. of Pts.**	**Age (years)**	**BMI (kg/m^2)**	**Tumour Size or Uterine Weight**	**Clinical Stage (FIGO)**
Halliday, 2010[86] Prospective observational (robotic) compared with historical cohort	Women with early stage cervical cancer	Da Vinci S (5-port technique; radical hysterectomy)	16	Mean 49 ± 10 (SD)	26 ± 6 (SD)	Uterine weight (g): Mean 155 ± 81 (SD)	Clinical stage: Ia1: 1 (6.3%) Ia2: 2 (12.5%) Ib1: 8 (50%) Ib2: 3 (18.8%) IIa: 2 (12.5%) FIGO grade: 1: 6 (38%) 2: 6 (38%) 3: 4 (24%)
		Open radical hysterectomy	24	Mean 47 ± 12 (SD)	25 ± 5 (SD)	Uterine weight (g): Mean 121 ± 73 (SD)	Clinical stage: Ia1: 2 (8%) (NS) Ia2: 1 (4%) Ib1: 18 (75%) Ib2: 2 (8%) IIa: 1 (4%) FIGO grade: 1: 3 (13%) (NS) 2: 10 (42%) 3: 11 (46%)
Holtz, 2010;[96] Retrospective comparison	Women with endometrial cancer	Da Vinci hysterectomy, bilateral salpingo-oophorectomy, pelvic and peri-aortic lymph node resection, and cystoscopy	13	Mean 63.5 ± 11.3 (SD)	Mean 35.3 ± 10.7 (SD)	Uterine weight (g): Mean 119 ± 54 (SD)	IA: 3 (23%) IB: 5 (39%) IC: 4 (31%) IIA:1 (8%) IIB:0 IIIA:0 FIGO grade: I: 6 (46%) 2: 3 (23%) 3: 4 (31%)
		Laparoscopic hysterectomy, bilateral salpingo-oophorectomy, pelvic and peri-aortic lymph node resection, and cystoscopy	20	Mean 63.3 ± 11.2 (SD)	Mean 27.8 ± 7.1; P=0.04 (SD)	Uterine weight (g): Mean 109 ± 54 (SD)	IA: 7 (35%) IB: 5 (25%) IC: 5 (25%) IIA: 0 IIB:2 (10%) IIIA: 1 (5%) FIGO grade: I: 14 (70%) 2: 1 (10%) 3: 4 (20%)
Jung, 2010;[105] Prospective observational	Women with clinical stage 1 endometrial cancer	Da Vinci-S	28	Mean 52.9 ± 11.9 (SD)	Mean 23.38 ± 3.08 (SD)	Uterine weight (g) : Mean 123.7 ± 61.2 (SD)	IA: 10 (36%) IB: 10 (36%) IC: 4 (14%) IIA: 1 (3.5%) IIB: 0 IIIA: 2 (7%) IIIB: 1 (3.5%)

Table A7: Patient Characteristics — Hysterectomy							
First Author, Year; Design	**Inclusion/ Exclusion Criteria**	**Comparison Arms**	**No. of Pts.**	**Age (years)**	**BMI (kg/m^2)**	**Tumour Size or Uterine Weight**	**Clinical Stage (FIGO)**
		Laparoscopic staging for endometrial cancer	25	Mean 49.9 ± 10.8 (SD)	Mean 25.17 ± 5.11 (SD)	Uterine weight (g) :Mean 118.1 ± 45.0 (SD)	IA: 11 (44%) IB: 7 (28%) IC: 2 (8%) IIA: 3 (12%) IIB: 1 (4%) IIIA: 1 (4%)
		Open surgery staging for endometrial cancer	56	Mean 50.2 ± 8.1 (SD)	Mean 24.82 ± 4.08 (SD)	Uterine weight (g) : Mean 157.5 ± 92.12 (SD)	IA: 18 (32%) IB: 25 (44%) IC: 9 (16%) IIA: 2 (4%) IIB: 0 IIIA: 2 (4%) IIIB: 0
Ko, 2008;[87] Retrospective comparison	Women with early stage cervical cancer	Da Vinci (type III radical hysterectomy)	16	Mean 42.3 ± 7.9 (SD)	Mean 27.6 ± 6.4 (SD)	Uterine weight (g): Mean 139.8 (range 90-286)	IA1: 1 (6.3%) IA2: 5 (31.3%) IB1: 10 (62.5%) (P=1.000)
		Open hysterectomy	32	Mean 41.7 ± 8.1 (SD) (P=0.795)	Mean 26.6 ± 5.9 (SD) (P=0.568)	Uterine weight (g): Mean 126.7 (range 56-480) (P=0.565)	IA1: 2 (6.3%) IA2: 10 (31.3.%) IB1: 19 (59.4%) IIA: 1 (3.1%)
Lowe, 2010;[88] Prospective observational	Women with early stage cervical cancer	Da Vinci	7	Reported only as no significant difference in median age	Reported only as no significant difference in median BMI	NR	IB1
		Open radical hysterectomy	7			NR	IB1
Maggioni, 2009;[89] Prospective observational (robotic) compared with historical cohort	Women newly diagnosed with invasive cervical cancer, FIGO stages 1A2-IIA	Da Vinci	40	Mean 44.1 ± 9.1 (SD)	Mean 24.1 ± 5.5 (SD)	Tumour size (cm): Mean 2.46 ± 1.44 (SD)	IA2=3 (7.5%) IB1=27 (67.5%) IB2=9 (22.5%) IIA=1 (2.5%)
		Open hysterectomy (radical and modified)	40	Mean 49.8 ± 14.1 (SD) (P=0.035)	Mean 23.6 ± 5.0 (SD) (P=0.669)	Tumour size (cm): Mean 3.314 ± 1.325 (SD)	IA2=1 (2.5%) (P=0.608) IB1=25 (62.5%) (P=0.815) IB2=12 (30%) (P=0.611) IIA=2 (5%) (P=1)
Nevadunsky, 2010;[90] Retrospective comparison	Obese and morbidly obese women with endometrial cancer	Da Vinci S (5 trocar placements)	66	Median 62 (range 35-89)	Median 38-9 (range 30-63)	Uterine weight (g): Mean 128 (range 57-314)	Clinical stage: I: 53 (87%) II: 2 (3%) II-IV: 6 (10%) FIGO grade: 1: 47 (71%) 2: 13 (20%) 3: 6 (9%)

Table A7: Patient Characteristics — Hysterectomy							
First Author, Year; Design	**Inclusion/ Exclusion Criteria**	**Comparison Arms**	**No. of Pts.**	**Age (years)**	**BMI (kg/m^2)**	**Tumour Size or Uterine Weight**	**Clinical Stage (FIGO)**
		Open total hysterectomy	43	Median 60 (range 39-86)	Median 37 (range 30-61)	Uterine weight (g): Mean 169 (range 20-942)	Clinical stage: I: 30 (81%) (NS) II: 1 (3%) II-IV: 6 (16%) FIGO grade: 1: 30 (70%) (NS) 2: 9 (21%) 3: 4 (9%)
Nezhat, 2009;[97] Retrospective comparison	Women undergoing laparoscopic hysterectomy	Da Vinci	26	Mean 46 (range 33-63)	Mean 25.4 (range 18-42)	NR	NR
		Laparoscopic hysterectomy	50	Mean 47 (range 39-74) (P=0.486)	Mean 26.7 (range 19-34) (P=0.246)	NR	NR
Payne, 2008;[98] Retrospective comparison	Women with a benign gynecologic condition (e.g., endometriosis, ovarian cysts, myomas, dysmenorrhea, dyspareunia)	Da Vinci	100	Mean 43.2 ± 9.4 (SD)	Mean 28.8 ± 6.2 (SD)	Uterine weight (g): Mean 266.6 ± 374.5 (SD)	NR
		Laparoscopic hysterectomy	100	Mean 43.5 ± 7.2 (SD)	Mean 28.8 ± 6.6 (SD)	Uterine weight (g): Mean 216.0 ± 172.9 (SD) (P=0.38)	NR
Schreuder, 2010;[91] Retrospective comparison	Women with early stage cervical cancer	Da Vinci	14	Median 43 (range 31-78)	NR	NR	Ib1: 11 Other: 1 endometrial cancer stage IIB, one stage Ib2 after neo-adjuvant chemo
		Open radical hysterectomy	14	Median 46 (range 32-68)	NR	NR	Ib1: 12 Other: 1 stage Ib2
Seamon, 2009;[99] Prospective observational (robotic) compared with historical	Women with clinical stage 1 or occult stage II endometrial cancer requiring	Da Vinci (hysterectomy and lymphadenectomy)	105	Mean 59 ± 8.9 (SD)	Mean 34.2 ± 9 (SD)	Tumour size (cm): Mean 3.8 ±1.8 (SD) Uterine weight (g): Mean 132 ± 64 (SD)	I: 87% II: 3% III and IV: 10%

Table A7: Patient Characteristics — Hysterectomy							
First Author, Year; Design	**Inclusion/ Exclusion Criteria**	**Comparison Arms**	**No. of Pts.**	**Age (years)**	**BMI (kg/m^2)**	**Tumour Size or Uterine Weight**	**Clinical Stage (FIGO)**
cohort	hysterectomy and lymphadenectomy	Laparoscopic hysterectomy and lymphadenectomy	76	Mean 57 ± 11 (SD) (P=0.098)	Mean 28.7 ± 6.9 (SD) (P=<0.001)	Tumour size (cm): Mean 3 ± 1.5 (SD) (P=0.009) Uterine weight (g): 133 ± 60 (SD) (P=0.97)	I 86% II: 5% (P=0.814) III and IV: 9%
Seamon, 2009;[92] Prospective observational	Obese women with clinical stage I or occult stage II endometrial cancer and BMI ≥ 30	Da Vinci (hysterectomy and lymphadenectomy)	109	Mean 58 ± 10.0 (SD)	Mean 39.6 ± 7.0 (SD)	NR	NR
		Open hysterectomy and lymphadenectomy	191	Mean 62 ± 11.5 (SD) (P=0.003)	Mean 39.9 ± 6.9 (SD)	NR	NR
Sert, 2007;[100] Prospective observational (robotic) compared with historical cohort	Women with early-stage cervical cancer	Da Vinci (radical hysterectomy and bilateral pelvic lymph node dissection)	7	? Mean 41	24.6	NR	IA1: 0 IA2: 3 (42.9%) IB1: 4 (57.1%)
		Laparoscopic total radical hysterectomy	7	45 (P=1.000)	22.5 (P=0.710)	NR	IA1: 2 (28.6%) IA2: 0 IB1: 5 (71.4%)
Shashaua, 2009;[101] Retrospective comparison	NR	Da Vinci	24	Mean 44.9 (range 27-74)	Mean 30.3 (range 18-46.3)	Uterine weight (g): Mean 212.1 (range 72-520)	NR
		Laparoscopic total hysterectomy	44	Mean 42.2 (range 24-78)	Mean 30.5 (range 18.6-47.7)	Uterine weight (g): Mean 170.4 (range 35-510) (P = 0.120)	NR
Veljovich, 2008;[93] Prospective observational (robotic) compared with historical cohort	Women with endometrial cancer	Da Vinci	25	Mean 59.5 (range 36-85)	Mean 27.6 (range 18.7-49.4)	Uterine weight (g): 106.5 (range 42-255)	NR
		Open hysterectomy	131	Mean 63 (range 30-92) (P=0.0725)	Mean 32.2 (range 16.4-65.8) (P=0.016)	Uterine weight (g): 125.9 (range 30-642) (P=0.0622)	NR

BMI=body mass index; cm=centimeters; FIGO=International Federation of Gynecology and Obstetrics; g=grams; No.=number; NR=not reported; NS=not significant; pts=patients; SD=standard deviation

Table A8: Patient Characteristics — Nephrectomy							
First Author, Year; Design	**Inclusion/ Exclusion Criteria**	**Comparison Arms**	**No. of Pts.; Men/ Women**	**Age (years)**	**BMI (kg/m^2)**	**Tumour Size**	**Clinical Stage**
Aron, 2008;[106] Retrospective comparison	Patients with single small unilateral renal mass	Da Vinci	12; 8/4	Mean 64 ± 13.8 (SD)	Mean 29 ± 6.4 (SD)	Mean 24mm ± 6.9 (SD)	NR
		Laparoscopic partial nephrectomy	12; 8/4	Mean 61 ± 13.8 (SD) (P=0.37)	Mean 30 ± 6.4 (SD) (P=0.76)	Mean 29 ± 7.1 (SD) (P=0.06)	NR
Benway, 2009;[107] Retrospective comparison	Patients with small renal masses	Da Vinci	129; NR	Mean 59.2	Mean 29.8	Mean 2.8 cm	NR
		Laparoscopic partial nephrectomy	118; NR	Mean 59.2	Mean 28.5	Mean 2.6 cm(P=NS)	NR
Deane, 2008;[108] Retrospective comparison	Patients with renal cell carcinoma (surgical approach: nephron-sparing)	Da Vinci (partial nephrectomy)	11; 10/1	Mean 53.2	NR	Mean 3.1 cm (range 2.5-4)	NR
		Laparoscopic partial/wedge nephrectomy	11; 7/4	Mean 54	NR	Mean 2.3 cm (range 1.7-6.2)	NR
DeLong, 2010;[109] Retrospective comparison	Patients with small renal mass (evaluated by CT) with no evidence for metastatic disease	Da Vinci transperitoneal partial nephrectomy	13; 8/5	Mean 59.7	Mean 28.9	Mean 2.6 cm	ASA class: Median 2.3
		Laparoscopic transperitoneal partial nephrectomy	15; 8/7	Mean 53.6	Mean 26.6	Mean 2.8 cm	ASA class: Median 2.3
Haber, 2010;[110] Retrospective comparison	Patients with small, localized renal masses	Da Vinci partial nephrectomy	75; 44/31	Mean 62.6	Mean 30.1	Mean 2.75 cm	NR
		Laparoscopic partial nephrectomy	75; 40/35	Mean 60	Mean 29.7	Mean 2.5 cm	NR
Hemal, 2009;[111] Prospective observational	Patients with clinical stage $T_{1-2}N_0M_0$ renal tumour, based on standard imaging	Da Vinci (radical nephrectomy)	15; 8/7	Mean 50.3 ± 10.2 (SD)	Mean 28.3 ± 4.5 (SD)	Mean 6.7 ± 2.3 cm; Specimen weight (g): 575 ± 25 (SD)	$T_{1-2}N_0M_0$: 100%

Table A8: Patient Characteristics — Nephrectomy							
First Author, Year; Design	**Inclusion/ Exclusion Criteria**	**Comparison Arms**	**No. of Pts.; Men/ Women**	**Age (years)**	**BMI (kg/m^2)**	**Tumour Size**	**Clinical Stage**
	criteria; patient preference determined placement in study arm	Laparoscopic radical nephrectomy	15; 6/9	Mean 52.7 ± 11.8 (SD) (P=515)	Mean 29.1 ± 3.4 (SD) (P=0.58)	Mean 6.9 ± 2.1cm (P=0.80); Specimen weight (g): 587 ± 28 (SD) (P=0.23)	$T_{1-2}N_0M_0$: 100%
Jeong, 2009;[112] Prospective observational	Patients with renal cell carcinoma	Da Vinci (partial nephrectomy)	31; Ratio of men: women= 0.94:1	?Mean 53.4	?Mean 24.1	?Mean 3.4 cm	NR
		Laparoscopic partial nephrectomy	15; Ratio of men: women= 1:1	58.7 (P=0.086)	24.8 (P=0.308)	2.4 cm (P=0.284)	NR
Kural, 2009;[113] Prospective observational	Patients with renal cell carcinoma	Da Vinci	11; 8/3	Mean 50.81 ± 13.15 (SD)	Mean 26.7 ± 3.8 (SD)	Mean 32.18 mm (range 20-41)	NR
		Laparoscopic partial nephrectomy (incl. 1 hand-assisted procedure)	20; 14/6	Mean 58.9 ± 15.4 (SD) (P=0.13)	Mean 27.8 ± 2.9 (SD) (P=0.44)	Mean 31.45 mm (range 15-70) (P=0.85)	NR
Nazemi, 2006;[115] Prospective observational	Patients with renal cancer requiring radical nephrectomy	Da Vinci	6; 5/1	Median 67.5 (44-78)	Median 27.6 (20.9-32.9)	Median 4.5 cm (range 2.8-5.5)	T1a: 2 (40%) T1b: 2 (40%) T3aM1:1 (20%)
		Open radical nephrectomy	18; 15/3	Median 57 (38-98)	Median 28.2 (15.9-50.3)	Median 5.5 cm (range 1.8-15)	T1a: 3 (21%) T1b: 4 (29%) T2: 3 (21%) T3a: 3 (21%) T3aM1:1 (7%)

Table A8: Patient Characteristics — Nephrectomy							
First Author, Year; Design	**Inclusion/ Exclusion Criteria**	**Comparison Arms**	**No. of Pts.; Men/ Women**	**Age (years)**	**BMI (kg/m^2)**	**Tumour Size**	**Clinical Stage**
		Laparoscopic nephrectomy with hand assistance	21; 15/6	Median 62 (27-81)	Median 29.2 (223.-46.9)	Median 4.25 cm (range 1.5-15)	T1a: 7 (47%) T1b: 3 (20%) T2: 3 (20%) T3a: 2 (13%)
		Laparoscopic nephrectomy	12; 9/3 (P=0.59)	Median 69 (43-76) (P=0.59)	Median 27.5 (19.2-39.8) (P=0.83)	Median 3.95 cm (range 2.3-15.0) (P=0.94)	T1a: 3 (38%) T1b: 1 (12) T2: 1 (12) T3a: 1 (12) T3b: 1 (12) T4: 1 (12) (P=0.70)
Wang, 2009;[114] Retrospective comparison	Patients with an enhancing renal mass or complex enhancing renal cyst	Da Vinci (partial nephrectomy)	40; NR	Mean 61	Mean 29.7	Mean 2.5 cm	NR
		Laparoscopic partial nephrectomy	62; NR	Mean 58	Mean 29.2	Mean 2.4 cm (P=NS)	NR

ASA=American Society of Anesthesiologists; BMI=body mass index; cm=centimeters; CT=computed tomography; g=grams; mm=millimeters; No.=number; NR=not reported; NS=not significant; pts=patients; SD=standard deviation

Table A9: Patient Characteristics — Cardiac Surgeries						
First Author, Year; Design	**Inclusion/Exclusion Criteria**	**Comparison Arms**	**No. of Pts.; Men/ Women**	**Age (years)**	**BMI (kg/m^2)**	**NYHA Class**
Ak, 2007;[116] Retrospective comparison	Patients with atrial septal defect	Da Vinci (totally endoscopic atrial septal repair)	24; 10/14	Mean 45.5 ± 17.0 (SD)	NR	Mean 1.4 ± 0.5 (SD)
		Partial lower sternotomy	16; 16/0	Mean 47.9 ± 17.2 (SD)	NR	Mean 1.5 ± 0.7 (SD)
		Right anterior small thoracotomy with transthoracic clamping	20; 7/13	Mean 48.2 ± 16.6 (SD)	NR	Mean 1.7 ± 0.7 (SD)
		Right anterior small thoracotomy with endoaortic balloon clamping	4; 0/4	Mean 37.6 ± 7 (SD) (P=0.261)	NR	Mean 2.3 ± 0.5 (SD) (P=0.204)
Folliguet, 2006;[118] Prospective observational (robotic) compared with historical cohort	Patients with posterior leaflet insufficiency involving only the P2 segment with no annulus calcifications, no coronary lesions, no aortic or tricuspid valve pathology, and absence of pulmonary disease in order to tolerate single lung ventilation	Da Vinci	25; 16/9	Mean 59.4 ± 11.2 (SD)	NR	I: 17 (68%) II: 6 (24%) III: 2 (8%)
		Sternotomy mitral valve repair	25; 17/8	Mean 60.4 ± 11.1 (SD) (P=0.82)	NR	I: 16 (64%) II: 5 (20%) III: 4 (16%)
Kam, 2010;[119] Retrospective comparison	Patients ≥ 18 years old; isolated MVR for degenerative mitral valve disease; operation was an elective procedure	Da Vinci mitral valve repair	104; 74/30	Mean 57.6 ± 13.67(SD)	NR	NR; Preop mitral regurgitation severity: Moderate-severe 5.8%; Severe 94.2%
		Conventional mitral valve repair	40; 33/7	Mean 61.6 ± 11.16 (SD)	NR	NR; Preop mitral regurgitation severity: Moderate-severe 17.5%; Severe 82.5%
Mihaljevic, 2011;[120] Retrospective comparison	Patients with degenerative MV disease limited to the posterior leaflet; patients undergoing concomitant procedures not included,	Da Vinci mitral valve repair	261; 204/57	Mean 56 ± 11 (SD)	Mean 26 ± 4.3 (SD)	I: 131 (50%) II: 97 (37%) III: 31 (12%) IV:2 (0.8%) LVEF (%): 60 ± 4.4 (SD)

Table A9: Patient Characteristics — Cardiac Surgeries						
First Author, Year; Design	**Inclusion/Exclusion Criteria**	**Comparison Arms**	**No. of Pts.; Men/ Women**	**Age (years)**	**BMI (kg/m^2)**	**NYHA Class**
	except for patent foramen ovale or atrial septal defect closure and left-sided ablative procedures for atrial fibrillation	Complete sternotomy	114; 85/29	Mean 61 ± 11 (SD)	Mean 27 ± 5.4 (SD)	I: 37 (32%) II: 54 (47%) III: 22 (19%) IV: 1 (0.9%) LVEF (%): 59 ± 5.7 (SD)
Morgan, 2004;[117] Prospective observational (robotic) compared with historical cohort	Patients ages 18-80 years with ostium secundum-type atrial septal defects (and mean Qp/Qs 1.5) or patent foramen ovale with a history of recurrent symptoms and a predominant right to left shunt. Large list of exclusion criteria that included anomalous pulmonary venous anatomy, sinus venosus type ASD, and persistent left superior vena cava; arteriosclerosis of the aorta or ileofemoral system, aortic regurgitation, and small-sized ileofemoral vessels	Da Vinci (atrial septal defect repair)	14; 3/11	Mean 44.1 ± 11.9 (SD) (P=0.708)	NR	NR; Size of defect (cm): 1.67 ± 0.53 (SD) (P=0.098)
		Sternotomy	14; 3/11	Mean 41.0 ± 14.9 (SD)	NR	NR; Size of defect (cm): 2.14 ± 0.67 (SD)
		Mini-thoracotomy	14; 3/11	Mean 45.2 ± 13.4 (SD)		NR; Size of defect (cm): 2.06 ± 0.47 (SD)
Poston, 2008;[123] Prospective observational	Multivessel coronary artery disease involving anterior and lateral coronary branches deemed suitable targets for grafting via mini-thoracotomy. Any additional coronary lesions must be deemed suitable for PCI/stenting. Exclusion: hemodynamically unstable; patients not suitable for complete revascularization; severe pulmonary and vascular disease; decompensated heart failure; significant arrhythmia; allergy to radiographic contrast	Da Vinci (mini-CABG)	99; 72/28	Mean 61.8 ± 9.4 (SD)	Mean 29.9 ± 9.7 (SD)	NR
		Off-pump CABG sternotomy	100; 63/37	Mean 66.2 ± 10.1 (SD) (P=NS)	Mean 28.4 ± 6.7 (SD) (P=NS)	NR

Table A9: Patient Characteristics — Cardiac Surgeries						
First Author, Year; Design	**Inclusion/Exclusion Criteria**	**Comparison Arms**	**No. of Pts.; Men/ Women**	**Age (years)**	**BMI (kg/m^2)**	**NYHA Class**
Tabata, 2006;[121] Retrospective comparison	Patients eligible for mitral valve repair	Da Vinci	5; NR	Mean 52.6 ± 17.3 (SD)	NR	NR
		Minimally invasive mitral valve	121; 47.4% men	Mean 75.6 ± 4.5 (SD) (range 70-89)	NR	2.4 ± 0.8 (ejection fraction: 58.5 ± 11.1%)
Woo, 2006;[122] Retrospective comparison	Patients requiring mitral valve reconstruction. Excluding: condition requiring concomitant coronary artery bypass grafting or aortic valve surgery	Da Vinci	25; 17/8	Mean 60 ± 3 (SE)	NR	NR
		Mitral valve repair via sternotomy	39; 24/15	Mean 60 ± 2 (SE) (P=0.44)	NR	NR

ASD=atrial septal defect; BMI=body mass index; CABG=coronary artery bypass graft; cm=centimetres; No.=number; NR=not reported; NS=not significant; NYHA=New York Heart Association; PCI=percutaneous coronary intervention; preop=pre-operative; pts=patients; SD=standard deviation; SE=standard error

Appendix 9: Subanalyses of Prostatectomy by Study Design, Study Quality, and Removal of Outliers

Table A10: Prostatectomy Outcomes Sub-analyses by Study Design						
Outcome	Retrospective			Prospective		
	No. of Studies	WMD or RR [95% CI]	Chi^2 Test (P value)	No. of Studies	WMD or RR [95% CI]	Chi^2 Test (P value)
Robot vs. Open						
• Operative time (min)	10	WMD: 20.09 [–16.27, 56.45]	<0.00001	6	WMD: 61.38 [33.66, 89.10]	<0.00001
• Hospital stay (days)	10	WMD: –1.22 [–1.80, –0.63]	<0.00001	7	WMD: –1.78 [–3.23, –0.34]	<0.00001
• Incidence of complications	6	RR: 0.63 [0.35, 1.14]	0.70	7	RR: 0.61 [0.45, 0.83]	0.02
• Incidence of transfusion	7	RR: 0.17 [0.09, 0.35]	0.04	9	RR: 0.18 [0.09, 0.36]	0.003
• Blood loss (mL)	10	WMD: –452.26 [–577.54, –326.98]	<0.00001	8	WMD: –443.99 [–573.04, –314.93]	<0.00001
• Urinary continence at 3 months	2	RR: 1.41 [0.67, 2.97]	0.006	3	RR: 1.13 [0.97, 1.31]	0.11
• Urinary continence at 12 months	2	RR: 1.01 [0.96, 1.08]	0.59	3	RR: 1.11 [1.05, 1.18]	0.97
• Sexual competence	1	RR: 1.75 [0.43, 7.08]	NA	3	RR: 1.84 [1.49, 2.28]	0.71
• Positive margin rate (all)	13	RR: 0.97 [0.68, 1.39]	0.001	7	RR: 1.15 [0.77, 1.70]	0.009
<u>*Sub-analysis by study design (Robot versus Open)*</u> • As compared with the findings in Table 1, when observational studies were pooled together, the associated chi-square tests showed a reduction in statistical heterogeneity in separate analyses of either retrospective or prospective studies for outcomes such as incidence of complications, incidence of transfusion, and sexual function. • The pooled estimates for outcomes such as operative time, incidence of complications, urinary continence at 12 months and sexual competence remain statistically significant among prospective studies, but not in retrospective studies. • Subgroup analyses based on study design had no effect on the pooled estimates of outcomes such as hospital length of stay, incidence of transfusion, blood loss, and positive margin rate (all). This suggests that these outcomes were not affected by study design.						
Robot vs. Laparoscopy						
• Operative time (min)	6	WMD: –34.12 [–67.95, –0.29]	<0.00001	2	WMD: –5.87 [–39.21, 27.47]	0.06
• Hospital stay (days)	5	WMD: –0.89 [–1.53, –0.25]	0.001	1	WMD: –0.20 [–0.79, 0.39]	NA
• Incidence of complications	6	RR: 1.06 [0.55, 2.06]	0.003	2	RR: 0.54 [0.20, 1.45]	0.90
• Incidence of transfusion	4	RR: 0.54 [0.29, 1.01]	0.56	2	RR: 0.50 [0.13, 1.96]	0.78
• Blood loss (mL)	7	WMD: –38.97 [–105.80, 27.87]	<0.00001	2	WMD: –276.12 [–555.40, 3.16]	0.0001

Table A10: Prostatectomy Outcomes Sub-analyses by Study Design						
Outcome	**Retrospective**			**Prospective**		
	No. of Studies	**WMD or RR [95% CI]**	**Chi^2 Test (P value)**	**No. of Studies**	**WMD or RR [95% CI]**	**Chi^2 Test (P value)**
• Urinary continence at 3 months	2	RR: 1.11 [0.79, 1.56]	0.01	1	RR: 1.10 [0.86, 1.41]	NA
• Urinary continence at 12 months	2	RR: 1.08 [0.99, 1.18]	0.27	0	NA	NA
• Positive margin rate	10	RR: 0.89 [0.66, 1.19]	0.55	0	NA	NA

<u>Sub-analysis by study design (Robot versus Laparoscopy)</u>

Studies comparing prospective cohorts of robotic surgery with historical cohorts of open surgery were removed from those of prospective design.

- As compared with the findings Table 5, when observational studies were pooled together (–89.5 [95% CI –157.5, –21.5], the pooled estimates for blood loss from both prospective (–276.1 [95% CI –555.4, 3.2]) and retrospective studies (–39.0 [95% CI –105.8, 27.9]) become inconclusive. Chi-square tests for both estimates showed statistically significant heterogeneity.
- The pooled estimates for incidence of transfusion from both prospective (0.50 [95% CI 0.13, 1.96]) and retrospective studies (0.54 [95% CI 0.29, 1.01]) also become inclonclusive compared to the pooled estimate when all studies were pooled together (0.54 [95% CI 0.31, 0.94]). Chi-square tests for both estimates did not suggest heterogeneity.
- Subgroup analyses based on study design had no effect in statistical heterogeneity of most outcomes and in the pooled estimates of outcomes such as operative time and incidence of complications.

CI=confidence interval; NA=not applicable; RR=risk ratio; WMD=weighted mean difference

Table A11: Prostatectomy Outcomes Sub-analyses by Study Quality						
Outcome	High to Good Quality (A, B)			Moderate to Low Quality (C, D, E)		
	No. of Studies	WMD or RR [95% CI]	Chi^2 Test (P value)	No. of Studies	WMD or RR [95% CI]	Chi^2 Test (P value)
Robot vs. Open						
• Operative time (min)	1	WMD: –8.90 [–27.33, 9.53]	NA	18	WMD: 40.37 [19.20, 61.54]	<0.00001
• Hospital stay (days)	2	WMD: –3.32 [–4.44, –2.21]	0.05	17	WMD: –1.24 [–1.66, –0.83]	<0.00001
• Incidence of complications	4	RR: 0.93 [0.52, 1.65]	0.10	11	RR: 0.66 [0.48, 0.92]	0.01
• Incidence of transfusion	3	RR: 0.36 [0.20, 0.66]	0.29	15	RR: 0.17 [0.11, 0.27]	0.001
• Blood loss (mL)	3	WMD: –406.58 [–630.54, –182.62]	<0.00001	18	WMD: –480.30 [–601.74, –358.86]	<0.00001
• Urinary continence at 3 months	2	RR: 1.11 [0.82, 1.50]	0.04	3	RR: 1.21 [0.94, 1.55]	0.03
• Urinary continence at 12 months	3	RR: 1.07 [0.98, 1.17]	0.04	5	RR: 1.05 [1.00, 1.11]	0.24
• Sexual competence	3	RR: 1.48 [0.98, 2.23]	0.0006	4	RR: 1.56 [1.28, 1.89]	0.65
• Positive margin rate (all)	6	RR: 1.04 [0.64, 1.70]	0.005	14	RR: 1.03 [0.75, 1.41]	0.001
Sub-analysis by study quality (Robot versus Open) • When the observational studies were analyzed separately based on study quality (high to good and moderate to low), the associated chi-square tests showed a reduction in statistical heterogeneity for most outcomes as compared to when studies of different quality were pooled together. • The pooled estimates for outcomes such as operative time, incidence of complications, urinary continence at 12 months and sexual competence remain statistically significant among studies of moderate to low quality, but not in those of high to good quality. • Subgroup analyses based on study quality had no effect on the pooled estimates of outcomes such as hospital length of stay, incidence of transfusion, blood loss, and positive margin rate (all). This suggests that these outcomes were not affected by study quality.						
Robot vs. Laparoscopy						
• Operative time (min)	2	WMD: –45.47 [–69.97, –20.97]	0.11	7	WMD: –15.84 [–40.89, 9.21]	<0.00001
• Hospital stay (days)	2	WMD: –1.50 [–1.92, –1.07]	0.65	5	WMD: –0.47 [–1.11, 0.17]	0.005
• Incidence of complications	2	RR: 0.88 [0.45, 1.72]	0.48	7	RR: 0.81 [0.40, 1.67]	0.004
• Incidence of transfusion	1	RR: 0.96 [0.27, 3.43]	NA	6	RR: 0.47 [0.25, 0.87]	0.89
• Blood loss (mL)	2	WMD: –153.35 [–314.94, 8.24]	0.02	8	WMD: –74.95 [–158.05, 8.15]	<0.00001
• Urinary	1	RR: 1.10	NA	2	RR: 1.11	0.01

Table A11: Prostatectomy Outcomes Sub-analyses by Study Quality						
Outcome	**High to Good Quality (A, B)**			**Moderate to Low Quality (C, D, E)**		
	No. of Studies	**WMD or RR [95% CI]**	**Chi^2 Test (P value)**	**No. of Studies**	**WMD or RR [95% CI]**	**Chi^2 Test (P value)**
continence at 3 months		[0.86, 1.41]			[0.79, 1.56]	
• Urinary continence at 12 months	1	RR: 1.04 [0.95, 1.15]	NA	1	RR: 1.15 [1.00, 1.32]	NA
• Positive margin rate	4	RR: 0.97 [0.60, 1.55]	0.94	6	RR: 0.76 [0.47, 1.23]	0.21

Sub-analysis by study quality (Robot versus Laparoscopy)

- When the studies of high to good quality were pooled, the associated chi-square tests showed no heterogeneity in outcomes such as operative time, hospital length of stay, and incidence of complications.
- The pooled estimates for outcomes such as operative time, and hospital length of stay remain statistically significant among studies of high to good quality, but not in those of moderate to low quality.
- The pooled estimates for incidence of transfusion remain statistically significant among studies of moderate to low quality, but not in those of high to good quality.
- The pooled estimates for blood loss from both high to low quality studies (–153.35 [95% CI –314.94, 8.24]) and moderate to low quality studies (–74.95 [95% CI –158.05, 8.15]) become inclonclusive compared to the pooled estimate when all studies were pooled together (–89.52 [95% CI –157.54, –21.49]). Chi-square tests for both estimates remain statistical heterogeneity.

CI=confidence interval; NA=not applicable; RR=risk ratio; WMD=weighted mean difference

Table A12: Prostatectomy Outcomes Sub-analyses by Removal of Outliers						
Outcome	**With Outliers**			**Without Outliers**		
	No. of Studies	**WMD or RR [95% CI]**	**Chi^2 Test (P value)**	**No. of Studies**	**WMD or RR [95% CI]**	**Chi^2 Test (P value)**
Robot vs. Open						
• Operative time (min)	19	WMD: 37.74 [17.13, 58.34]	<0.00001	16	WMD: 22.92 [1.87, 43.98]	<0.00001
• Length of stay (days)	19	WMD: –1.54 [–2.13, –0.94]	<0.00001	18	WMD: –1.41 [–2.01, –0.82]	<0.00001
• Incidence of complications	15	RR: 0.73 [0.54, 1.00]	0.0004	14	RR: 0.72 [0.53, 0.98]	0.0004
• Incidence of transfusion	18	RR: 0.20 [0.14, 0.30]	0.0002	17	RR: 0.22 [0.15, 0.30]	0.01
• Blood loss (mL)	21	WMD: –470.26 [–587.98, –352.53]	<0.00001	17	WMD: –521.72 [–613.31, –430.14]	<0.00001
• Urinary continence at 3 months	5	RR: 1.15 [0.99, 1.34]	0.03	4	RR: 1.06 [0.79, 1.41]	0.15
• Urinary continence at 12 months	8	RR: 1.06 [1.02, 1.10]	0.11	8 No outlier		
• Sexual competence	7	RR: 1.55 [1.20, 1.99]	0.003	5	RR: 1.53 [1.17, 2.00]	0.0007
• Positive margin rate (all)	20	RR: 1.04 [0.80, 1.34]	0.0001	17	RR: 1.00 [0.77, 1.29]	<0.0001
Sub-analysis by removal of outliers (Robot versus Open) Sub-analysis by removal of outliers had no effect in statistical heterogeneity and pooled estimates of most outcomes.						
Robot vs. Laparoscopy						
• Operative time (min)	9	WMD: –22.79 [–44.36, –1.22]	<0.00001	8	WMD: –13.30 [–30.88, 4.28]	<0.00001
• Length of stay (days)	7	WMD: –0.80 [–1.33, –0.27]	0.0003	6	WMD: –1.01 [–1.46, –0.56]	0.02
• Incidence of complications	9	RR: 0.85 [0.50, 1.44]	0.01	9 No outlier		
• Incidence of transfusion	7	RR: 0.54 [0.31, 0.94]	0.83	7 No outlier		
• Blood loss (mL)	10	WMD: –89.52 [–157.54, –21.49]	<0.00001	7	WMD: –92,59 [–122.99, –62.18]	0.15
• Urinary continence at 3 months	3	RR: 1.10 [0.90, 1.34]	0.05	3 No outlier		
• Urinary continence at 12 months	2	RR: 1.08 [0.99, 1.18]	0.27	2 No outlier		
• Positive margin rate	10	RR: 0.89 [0.66, 1.19]	0.55	10 No outlier		
Sub-analysis by removal of outliers (Robot versus Laparoscopy) Removal of the outliers (Rozet, Durand and Ploussard) for blood loss changed the pooled estimate from statistical heterogeneity to non-heterogeneity.						
CI=confidence interval; NA=not applicable; RR=risk ratio; WMD=weighted mean difference						

Appendix 10: Subanalyses of Hysterectomy by Study Design, Study Quality, and Removal of Outliers

Table A13: Hysterectomy Outcomes Sub-analyses by Study Design						
Outcome	**Retrospective**			**Prospective**		
	No. of Studies	**WMD or RR [95% CI]**	**Chi^2 Test (P value)**	**No. of Studies**	**WMD or RR [95% CI]**	**Chi^2 Test (P value)**
Robot (all) vs. Open (all)						
• Operative time (min)	6	WMD: 81.57 [39.95, 123.20]	<0.00001	3	WMD: 52.75 [–0.86, 106.35]	<0.00001
• Hospital stay (days)	6	WMD: –2.25 [–2.71, –1.80]	<0.0001	3	WMD: –3.76 [–5.77, –1.76]	<0.00001
• Incidence of complications	5	RR: 0.24 [0.14, 0.43]	0.66	3	RR: 0.37 [0.21, 0.65]	0.89
• Incidence of transfusion	4	RR: 0.19 [0.07, 0.51]	0.75	3	RR: 0.32 [0.15, 0.67]	0.92
• Blood loss (mL)	5	WMD: –202.92 [–290.21, –115.62]	<0.00001	2	WMD: –232.53 [–353.44, –111.62]	0.03
<u>*Sub-analysis by study design*</u> *(Robot (all) vs. Open (all))* Studies comparing prospective cohort of robotic surgery with historical cohort of open surgery were removed from those of prospective design. Separate analysis of retrospective and prospective studies did not change the pooled estimates of all outcomes and the associated chi-square tests for heterogeneity.						
Robot (all) vs. Laparoscopy (all)						
• Operative time (min)	7	WMD: 28.26 [8.27, 48.26]	<0.00001	1	WMD: 27.98 [–0.13, 56.09]	NA
• Hospital stay (days)	7	WMD: –0.27 [–0.44, –0.09]	0.02	0	NA	NA
• Incidence of complications	2	RR: 0.48 [0.14, 1.66]	0.22	1	RR: 0.89 [0.14, 5.88]	NA
• Incidence of transfusion	2	RR: 0.97 [0.29, 3.19]	0.31	1	RR: 0.89 [0.25, 3.20]	NA
• Blood loss (mL)	7	WMD: –58.77 [–84.23, –33.31]	0.13	0	NA	NA
<u>*Sub-analysis by study design*</u> *(Robot (all) vs. Laparoscopy (all))* Studies comparing prospective cohort of robotic surgery with historical cohort of open surgery were removed from those of prospective design. • Compared with the pooled estimate when all studies were analyzed together (Table 9), the pooled estimate for operative time of retrospective studies became statistically significant, but the associated chi-square for heterogeneity did not change. • For other outcomes, sub-analysis by study design did not change the corresponding pooled estimates and the associated chi-square tests for heterogeneity.						
CI=confidence interval; NA=not applicable; RR=risk ratio; WMD=weighted mean difference						

Table A14: Hysterectomy Outcomes Sub-analyses by Study Quality						
Outcome	High to Good Quality (A, B)			Moderate to Low Quality (C, D, E)		
	No. of Studies	WMD or RR [95% CI]	Chi^2 Test (P value)	No. of Studies	WMD or RR [95% CI]	Chi^2 Test (P value)
Robot (all) vs. Open (all)						
• Operative time (min)	4	WMD: 55.31 [38.50, 72.11]	0.10	12	WMD: 66.44 [37.14, 95.74]	<0.00001
• Hospital stay (days)	4	WMD: –2.69 [–4.22, –1.16]	<0.0001	12	WMD: –2.72 [–3.13, –2.30]	<0.00001
• Incidence of complications	4	RR: 0.60 [0.44, 0.82]	0.43	10	RR: 0.29 [0.21, 0.41]	0.79
• Incidence of transfusion	3	RR: 0.23 [0.09, 0.62]	0.55	8	RR: 0.25 [0.14, 0.45]	0.93
• Blood loss (mL)	4	WMD: –285.78 [–432.94, –138.62]	<0.0001	10	WMD: –210.01 [–265.27, –154.75]	<0.00001
<u>Sub-analysis by study quality</u> (Robot (all) vs. Open (all)) Separate analysis of studies of high or good quality and studies of moderate or low quality did not change the pooled estimates of all outcomes and the associated chi-square tests for heterogeneity.						
Robot (all) vs. Laparoscopy (all)						
• Operative time (min)	2	WMD: 36.82 [–9.17, 82.80]	0.002	11	WMD: 6.77 [–13.95, 27.48]	<0.00001
• Hospital stay (days)	2	WMD: –0.20 [–0.86, 0.46]	0.19	9	WMD: –0.22 [–0.39, –0.05]	0.001
• Incidence of complications	1	RR: 0.80 [0.26, 2.44]	NA	4	RR: 0.48 [0.25, 0.91]	0.57
• Incidence of transfusion	2	RR: 1.68 [0.41, 6.92]	0.98	3	RR: 0.42 [0.15, 1.15]	0.21
• Blood loss (mL)	2	WMD: –78.16 [–108.52, –47.80]	0.98	9	WMD: –55.47 [–77.14, –33.80]	0.22
<u>Sub-analysis by study quality</u> (Robot (all) vs. Laparoscopy (all)) Separate analysis of studies of high or good quality and studies of moderate or low quality did not change the pooled estimates of outcomes such as operative time, incidence of transfusion and blood loss, and the associated chi-square tests for heterogeneity.						
CI=confidence interval; NA=not applicable; RR=risk ratio; WMD=weighted mean difference						

Table A15: Hysterectomy Outcomes Sub-analyses by Removal of Outliers						
Outcome	**With Outliers**			**Without Outliers**		
	No. of Studies	**WMD or RR [95% CI]**	**Chi^2 Test (P value)**	**No. of Studies**	**WMD or RR [95% CI]**	**Chi^2 Test (P value)**
Robot (all) vs. Open (all)						
• Operative time (min)	16	WMD: 63.57 [40.91, 86.22]	<0.00001	12	WMD: 73.74 [57.27, 90.22]	<0.00001
• Hospital stay (days)	16	WMD: –2.69 [–3.08, –2.30]	<0.00001	16 No outlier		
• Peri-op complications	14	RR: 0.38 [0.27, 0.52]	0.10	14 No outlier		
• Rate of transfusion	11	RR: 0.25 [0.15, 0.41]	0.96	11 No outlier		
• Blood loss (mL)	14	WMD: –222.03 [–270.84, –173.22]	<0.00001	11	WMD: –179.26 [–221.00, –137.52]	<0.00001
<u>Sub-analysis by removal of outliers</u> (Robot (all) vs. Open (all)) Removal of the outliers for operative time (Boggess 2, Geisler, Jung, and Schreuder) and for blood loss (Ko, Estape, and Halliday) did not change the corresponding pooled estimates and the associated chi-square tests for heterogeneity.						
Robot (all) vs. Laparoscopy (all)						
• Operative time (min)	13	WMD: 11.46 [–7.95, 30.87]	<0.00001	9	WMD: 33.20 [19.95, 46.44]	<0.00001
• Hospital stay (days)	11	WMD: –0.22 [–0.38, –0.06]	0.002	9	WMD: –0.25 [–0.39, –0.11]	0.01
• Peri-op complications	5	RR: 0.54 [0.31, 0.95]	0.62	5 No outlier		
• Rate of transfusion	5	RR: 0.62 [0.26, 1.49]	0.20	5 No outlier		
• Blood loss (mL)	11	WMD: –60.96 [–78.37, –43.54]	0.28	11 No outlier		
<u>Sub-analysis by removal of outliers</u> (Robot (all) vs. Laparoscopy (all)) Removal of outliers did not change the associated chi-square tests for heterogeneity.						
CI=confidence interval; NA=not applicable; RR=risk ratio; WMD=weighted mean difference						

Appendix 11: Subanalyses of Nephrectomy by Study Design, Study Quality, and Removal of Outliers

Table A16: Nephrectomy Outcomes Sub-analyses by Study Design

Outcome	Retrospective			Prospective		
	No. of Studies	WMD or RR [95% CI]	Chi^2 Test (P value)	No. of Studies	WMD or RR [95% CI]	Chi^2 Test (P value)
Robot vs. Laparoscopy						
• Operative time (min)	7	WMD: 1.89 [–16.50, 20.29]	<0.00001	2	WMD: –3.81 [–74.23, 66.61]	0.0001
• Hospital stay (days)	7	WMD: –0.25 [–0.50, –0.01]	<0.00001	2	WMD: –0.20 [–0.60, 0.19]	0.52
• Incidence of complications	5	RR: 1.30 [0.77, 2.20]	0.29	1	RR: 0.91 [0.09, 8.93]	NA
• Incidence of transfusion	2	RR: 1.20 [0.18, 7.82]	0.26	2	RR: 0.53 [0.07, 3.88]	0.71
• Blood loss (mL)	7	WMD: –14.16 [–55.70, 27.38]	0.0002	2	WMD: –29.79 [–103.43, 43.84]	0.29
• Warm ischemic time (mins)	6	WMD: –5.26 [–9.24, –1.28]	0.001	2	WMD: –1.71 [–13.59, 10.17]	0.02

<u>Sub-analysis by study design</u> *(Robot vs. Laparoscopy)*

Compared with the pooled estimate when all studies were analyzed together (Table 11), the pooled estimate for all outcomes of retrospective studies and the associated chi-square for heterogeneity remained unchanged.

CI=confidence interval; NA=not applicable; RR=risk ratio; WMD=weighted mean difference

Table A17: Nephrectomy Outcomes Sub-analyses by Study Quality

Outcome	High to Good Quality (A, B)			Moderate to Low Quality (C, D, E)		
	No. of Studies	WMD or RR [95% CI]	Chi^2 Test (P value)	No. of Studies	WMD or RR [95% CI]	Chi^2 Test (P value)
Robot vs. Laparoscopy						
• Operative time (mins)	1	WMD: 15.00 [5.20, 24.80]	NA	7	WMD: –0.76 [–25.39, 23.87]	<0.00001
• Hospital stay (days)	1	WMD: –0.30 [–0.41, –0.19]	NA	7	WMD: –0.28 [–0.41, –0.19]	<0.00001
• Peri-op complications	1	RR: 0.84 [0.38, 1.83]	NA	4	RR: 1.20 [0.68, 2.14]	0.94
• Rate of transfusion	1	RR: 0.46 [0.04, 4.98]	NA	3	RR: 1.10 [0.24, 5.07]	0.50
• Blood loss (mL)	1	WMD: –41.00 [–70.12, –11.88]	NA	7	WMD: –18.70 [–75.88, 38.49]	0.0005
• Warm ischemic time (mins)	1	WMD: –10.80 [–14.28, –7.32]	NA	7	WMD: –2.69 [–6.20, 0.83]	0.008

<u>Sub-analysis by study quality</u>*(Robot vs. Laparoscopy)*

High or good quality study (Benway) showed significant difference for outcomes such as operative time, hospital length of stay, blood loss and warm ischemic time.

CI=confidence interval; NA=not applicable; RR=risk ratio; WMD=weighted mean difference

Table A18: Nephrectomy Outcomes Sub-analyses by Removal of Outliers						
Outcome	**Including Outliers**			**Excluding Outliers**		
	No. of Studies	**WMD or RR [95% CI]**	**Chi^2 Test (P value)**	**No. of Studies**	**WMD or RR [95% CI]**	**Chi^2 Test (P value)**
Robot vs. Laparoscopy						
• Operative time (min)	9	WMD: 1.42 [–15.78, 18.62]	<0.00001	9 No outlier		
• Hospital stay (days)	9	WMD: –0.25 [–0.47, –0.03]	<0.0001	9 No outlier		
• Peri-op complications	6	RR: 1.24 [0.74, 1.93]	0.41	6 No outlier		
• Rate of transfusion	4	RR: 0.85 [0.24, 3.09]	0.62	4 No outlier		
• Blood loss (mL)	9	WMD: –17.44 [–53.63, 18.75]	0.0005	7	WMD: –31.49 [–49.58, –13.41]	0.40
• Warm ischemic time (min)	8	WMD: –4.18 [–8.17, –0.18]	<0.00001	6	WMD: –6.54 [–10.37, –2.71]	0.004

<u>Sub-analysis by removal of outliers</u>*(Robot vs. Laparoscopy)*

- For blood loss, two studies (Aron[106], Haber[110]) had positive weighted mean differences. Upon removal of these two outliers, the pooled estimates became significantly different and the chi-square test showed no heterogeneity.
- For warm ischemic time, removal of outliers (Aron[106]. Jeong[112]) did not affect the pooled estimate and the associated chi-square test.

CI=confidence interval; NA=not applicable; RR=risk ratio; WMD=weighted mean difference

Appendix 12: Economic Review Data Extraction Form

Reference ID	
Author	
Title	
Publication source	
Publication type	
Reviewer	
Date	
Study characteristics	
1. Study question/objective	
2. Study indication	
3. Study population selection criteria	
4. Study population characteristics	
5. Disease risk of included study population	
6. Study intervention	
7. Study comparator	
8. Analysis type	
9. Currency and its year	
10. Care setting or study geographic location	
11. Study perspective	
12. Discounting rate and justification	
13. Analysis time horizon	
Source of data	
14. Source of effectiveness data	
15. Source of cost data	
Method for estimation of benefits/costs	
16. Health outcomes	
17. If CBA study, status of outcomes or benefits	
18. Valuation for clinical effectiveness of intervention	
19. Approach for health state assessment	
20. The content of cost considered in the study	
21. Modelling (if model used)	
22. Sensitivity analysis type	
23. Key parameters on which sensitivity analysis was done on	
24. Statistical analysis	
25. Sub-group analysis (if applicable)	
26. Regression analysis (if applicable)	
Results and analysis	
27. Clinical outcome/benefits	
28. Costs	
29. Synthesis of costs and benefits	
30. Health related quality of life benefits	
31. Statistical analysis results	
32. Sensitivity analysis results	
33. Sub-group analysis results	
34. Regression analysis results	
Conclusion	
35. Conclusion	
36. Limitations	
37. Funding source (if applicable)	

Appendix 13: Studies Excluded from the Economic Review

Table A19: Studies Excluded from Economic Review		
Author	**Title/Source**	**Reason for Exclusion**
Bolenz et al. (2009)[215]	Cost comparison of robotic, laparoscopic, and open radical prostatectomy. Eur Urol Suppl 2009;8(4):364	Abstract of full report published by Bolenz et al.[129]
Link et al. 2006)[216]	A prospective comparison of robotic and laparoscopic pyeloplasty. Ann Surg 2006, 243: 486-491.	Not a selected indication
Kural et al. (2009)[113]	Robot-assisted partial nephrectomy versus laparoscopic partial nephrectomy: comparison of outcomes. J Endourol 2009, 23(9): 1491-1497	Not an economic evaluation
Gettman et al. (2007)[217]	Critical comparison of laparoscopic, robotic, and open radical prostatectomy: techniques, outcomes, and costs. Current Prostate Reports 2007, 5:61-67	Not an economic evaluation
Uranus et al. (2002)[218]	Early experience with telemanipulative abdominal and cardiac surgery with the Zeus robotic system. Eur Surg 2002, 34: 190-193.	Not an evaluation of the da Vinci robot
Onnasch et al. (2002)[219]	Five years of less invasive mitral valve surgery: from experimental to routine approach. Heart Surg Forum 2002, 5(2): 132-135.	Not an economic evaluation
Sur et al. (2006)[220]	Sur RL, Scales CD, Haleblian GE, Jones PJ, Borawski KM, Eisenstein EL, et al. Local cost structures and the economics of robot assisted radical prostatectomy. Abstract presented at: Annual Meeting of the American Urological Association. 2006 May 20-25; Atlanta, GA.	Duplicate of full study published by Scales et al.[136]
Zebrowski et al. (2004)[221]	Da Vinci robotic surgical experience at a university setting: first one hundred cases. Gastroenterology 2004; 126(4 Suppl 2)	Data not specific enough with respect to indications
Sur et al. (2005)[222]	Local cost structures and economics of robot assisted radical prostatectomy. J Endourol 2005; 19(Suppl 1)	Duplicate of full report published by Scales et al.[136]
Joseph et al. (2005) [223]	Robot-assisted radical prostatectomy (RAP): is this a cost-viable option? J Endourol 2005; 19(Suppl 1)	Abstract of full report published by Joseph et al.[141]
Joseph et al. (2005)[224]	Joseph JV, Rosenbaum R, Vicente I, Madeb RR, Erturk E, Patel HRH. Cost-profit analysis of davinci robotic surgery: Is it worth it? Poster presented at: Annual Meeting of the American-Urological-Association, May 21 -26, 2005. 2005; San Antonio, TX.	Not a comparative evaluation
Bernstein et al. (2005)[225]	Bernstein AJ, Kernen KM, Gonzalez J, Balasubramaniam M. A cost and revenue analysis for retropubic, perineal and robotic prostatectomy at a large community hospital [San Antonio, TX]. *J Urol*. 2005;173(4 Suppl S):7.	Not a comparison of costs, but an analysis of determinants of costs
Atug et al. (2005)[226]	Cost-analysis of radical retropubic, perineal, and robotic laparoscopic prostatectomy: a single institution analysis. Eur Urol Suppl 2005; 4(3)	Earlier version of Burgess et al.[135]
Morgan et al. (2003)[227]	Does robotic technology make minimally invasive cardiac surgery too expensive? A hospital cost analysis of robotic and conventional techniques. J Am Col Cardiol 2003; 41(6 Suppl A)	Earlier version of Morgan et al.[145]
Parsons et al. (2007)[228]	Parsons JK, Bennett L. Outcomes of radical retropubic, laparoscopic, and robotic-assisted prostatectomy: A quantitative, evidence-based analysis [abstract] [Anaheim, CA]. *J Urol*. 2007;177(4 Suppl S):4.	Not an economic evaluation

Note: Poston et al.[123] was retrieved twice, and one copy was excluded as a duplicate.

Appendix 14: Assessment of Quality of Reporting of Studies in Economic Review

BMJ Guidelines for Economic Submissions (Drummond and Jefferson, BMJ 1996)[127]

SCORING	
1.0	**Reported**
0.5	**Partially reported or unclear**
0.0	**Not reported**
na	**Not applicable**

		Bolenz 2010a[139]	Hohwu 2010 (abstract)[140]	Laungani 2010 (abstract)[142]	Bolenz 2010b[129]	Lotan 2009[143]	Ollendorf 2009[130]	Joseph 2008[141]	Steinberg 2008[131]	Mayer 2007 (abstract)[132]	Mouraviev 2007[133]	O'Malley 2007[134]	Burgess 2006[135]	Scales 2005[136]	Guru 2004 (abstract)[137]	Lotan 2004[138]
Study Design																
1	Research question stated	1	1	1	1	1	1	1	1	0.5	0.5	0.5	1	1	0.5	1
2	Economic importance of research question stated	1	1	1	1	1	1	1	1	1	0.5	1	1	1	1	1
3	Viewpoint(s) of analysis clearly stated and justified	0	0	1	0.5	1	1	0	0.5	0.5	0	0	0.5	0.5	0	0
4	Rationale for alternative interventions stated	0.5	1	0.5	1	1	1	1	1	0	1	1	1	1	0.5	1
5	Alternatives clearly described	0.5	0	0	0.5	0.5	1	0.5	0	0	0	0	0	0.5	0	0.5
6	Form of economic evaluation used is stated	0	1	0	0.5	0.5	1	0	1	0	1	1	1	1	0.5	0.5
7	Choice of economic evaluation justified in relation to question addressed	0	0.5	0.5	0.5	1	1	0.5	0.5	0	0	1	0.5	0.5	0	0.5
Data Collection																
8	Source(s) of effectiveness estimates stated	1	0.5	0	0.5	na	1	0.5	0	na	0.5	1	0.5	na	na	1
9	Details of design and results of effectiveness study given (if based on single study)	1	0.5	0	na	na	1	0.5	0	na	0	0.5	0	na	na	na
10	analysis of estimates (if based on a number of effectiveness studies)	na	na	na	na	na	0.5	na	na	na	na	na	na	na	na	1
11	evaluation clearly stated	na	1	na	na	na	1	na	1	na	na	0.5	na	na	na	na
12	Methods to value health states & other	0.5	0.5	na	na	na	1	na	na	na	0	0.5	0	na	na	na
13	obtained stated	1	0	0	0.5	0	1	0	na	0	0.5	0	0	0	0	0
14	Productivity changes (if included) reported separately	na	na	na	na	na	0.5	na	na	na	na	1	na	na	na	na
15	Relevance of productivity change to study discussed	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
16	unit costs	0.5	0	0	0.5	0	1	0	0.5	0	0	0.5	0.5	1	0	1
17	Methods for estimating resources and unit	0.5	0	0	1	1	1	1	0.5	0	0	0.5	0	1	0.5	1
18	Currency and price date recorded	0.5	0	0	1	0.5	0.5	0.5	0.5	0	0	0	0	0.5	0	0.5
19	Details of currency of price adjustment for inflation or currency conversion given	0.5	0	0	0.5	0	0.5	0	0	0	0	0	0	0	0	0
20	Details of any model used given	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
21	Choice of model & key parameters on which based justified	0.5	0	0	0	0.5	1	0	0	0	0	0	0	0.5	0	0.5
Analysis and Interpretation of Results																
22	Time horizon of costs and benefits stated	0	1	0	0	1	1	0	0	0	0	0	0	0	0	0
23	Discount rate(s) stated	na	na	na	na	na	1	na	na	na	na	na	na	na	na	na
24	Choice of rate(s) justified	na	na	na	na	na	1	na	na	na	na	na	na	na	na	na
25	discounted	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
26	stochastic data	1	0	0	1	0.5	0.5	0.5	0	na	0.5	0	0.5	na	0.5	na
27	Approach to sensitivity analysis given	na	0.5	na	na	na	0	na	0.5	na	na	na	na	1	na	1
28	Choice of variables for sensitivity analysis justified	na	0	na	na	na	0	na	0.5	na	na	na	na	1	na	1
29	Ranges over which variables are varied are stated	na	0	na	na	na	0	na	1	na	na	na	na	1	na	0.5
30	Relevant alternatives compared	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
31	Incremental analysis reported	na	0.5	na	na	na	1	na	na	na	na	1	na	na	na	na
32	Major outcomes presented disaggregated & aggregated	1	0	0.5	0.5	0.5	1	0.5	0.5	0	0.5	0.5	0.5	1	0	1
33	Answer to study question given	1	1	0.5	1	1	0.5	1	1	0.5	1	0.5	1	1	1	1
34	Conclusions follow from data reported	1	0.5	0.5	1	1	0.5	0.5	0.5	0.5	0.5	0	0.5	1	0.5	1
35	Conclusions accompanied by appropriate caveats	1	0	0	0.5	0	0.5	0.5	1	0	1	0.5	0.5	1	0	1

BMJ Guidelines for Economic Submissions (Drummond and Jefferson, BMJ 1996)

SCORING
1.0 Reported
0.5 Partially reported or unclear
0.0 Not reported
na Not applicable

		Bachinsky 2010 (abstract)[144]	Kam 2010[119]	Poston 2008[123]	Morgan 2005[145]	Boger 2010[146]	Nazemi 2006[115]	Prewitt 2008[58]	Barnett 2010[147]	Halliday 2010[86]	Hotlz 2010[96]	Pasic 2010[148]	Raju 2010[149]	Wright 2010 (abstract)[150]	Sarlos 2010[151]	Bell 2008[102]
Study Design																
1	Research question stated	0.5	1	1	1	1	1	1	1	1	1	1	1	1	0.5	1
2	Economic importance of research question stated	0	1	1	1	0	0	1	1	1	0.5	1	0	0	0	0
3	Viewpoint(s) of analysis clearly stated and justified	0	0.5	0	1	0	0	1	1	0	1	1	0	0	0.5	0.5
4	Rationale for alternative interventions stated	0.5	1	1	1	1	1	1	1	1	1	1	0	0	1	0.5
5	Alternatives clearly described	0.5	0.5	1	0	0.5	0.5	1	0.5	1	1	0.5	0	0.5	1	0
6	Form of economic evaluation used is stated	0	0.5	1	0.5	0.5	0	0.5	1	0	1	1	0	0	0	0
7	Choice of economic evaluation justified in relation to question addressed	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1	0.5	0.5	0.5	0	0.5	0	0
Data Collection																
8	Source(s) of effectiveness estimates stated	1	1	1	na	1	1	na	1	1	1	1	na	0.5	1	1
9	Details of design and results of effectiveness study given (if based on single study)	0.5	0.5	1	na	0.5	0.5	na	na	1	0.5	1	na	0	1	0.5
10	analysis of estimates (if based on a number of effectiveness studies)	na	na	na	na	na	na	na	0.5	na	na	na	na	na	na	na
11	evaluation clearly stated	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
12	Methods to value health states & other	na	na	1	na	na	na	na	na	na	na	na	na	na	1	0
13	obtained stated	0.5	1	1	1	1	1	0	0	1	1	1	0	0.5	1	1
14	Productivity changes (if included) reported separately	na	na	1	na	na	na	na	1	na	na	na	na	na	na	1
15	Relevance of productivity change to study discussed	0	0	0	0.5	0	0	0	1	0	0	0	0	0	0	1
16	unit costs	0	0	0	0	0	0	0	1	0.5	0	0	0	0	0	0
17	Methods for estimating resources and unit	0	0.5	0.5	0.5	0	0	0.5	1	1	0.5	0.5	0.5	0.5	0	0.5
18	Currency and price date recorded	0	1	0.5	0	0	0	0	1	0.5	0	0	0	0	0	0
19	Details of currency of price adjustment for inflation or currency conversion given	0	0.5	0	0	0	0	0	0.5	0	0	0	0	0	0	0
20	Details of any model used given	0.5	0	0	0	0	0	0	1	0.5	0	0	0	0	0	0
21	Choice of model & key parameters on which based justified	0	0	0	0.5	0	0	0	1	0	0	0	0	0	0	0
Analysis and Interpretation of Results																
22	Time horizon of costs and benefits stated	0	0	0.5	0.5	0	0	0	0.5	0	0	1	0	0	0	0
23	Discount rate(s) stated	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
24	Choice of rate(s) justified	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
25	discounted	na	na	na	na	na	na	na	na	na	na	na	na	na	na	na
26	stochastic data	0.5	1	0.5	0.5	1	1	0	na	1	1	0.5	na	0.5	0.5	1
27	Approach to sensitivity analysis given	na	na	na	na	na	na	na	1	1	na	na	na	na	na	na

Appendix 15: Economic Review External Validity Checklist

Table A20: Economic Review External Validity Checklist				
Author/Year	Does the Research Question Reflect the Issue Presently Concerned?	Did the Clinical Data Used in the Analysis Reflect What Might Be Achieved in the Routine Clinical Practice in Canada?	Are Resource Use Pattern and Relative Unit Cost Levels Generalizable to Canada?	Is Uncertainty Adequately Reflected in the Analysis?
Bolenz (2010)[139]	Partial	Partial	Partial	No
Hohwü (2010)[140]	Yes	Partial	Partial	Partial
Laungani (2010)[142]	Yes	Clinical outcomes not reported	Partial	No
Bolenz (2010)[129]	Yes	Partial	Partial	No
Lotan (2010)[143]	Yes	Clinical outcomes not reported	Partial	No
Ollendorf (2009)[130]	Yes	Partial	Partial	No
Joseph (2008)[141]	Yes	Partial	Partial	No
Steinberg (2008)[131]	Partial	Clinical outcomes not reported	Partial	Partial
Mayer (2007)[132]	Partial	Clinical outcomes not reported	Partial	No
Mouraviev (2007)[133]	Yes	Partial	Partial	No
O'Malley (2007)[134]	Yes	Partial	Partial	No
Burgess (2006)[135]	Yes	Partial	Partial	No
Scales (2005)[136]	Partial	Clinical outcomes not reported	Partial	Partial
Guru (2004)[137]	Yes	Clinical outcomes not reported	Partial	No
Lotan (2004)[138]	Yes	Clinical outcomes not reported	Partial	Partial
Bachinsky (2010)[144]	Yes	Partial	Partial	No
Kam (2010)[119]	Yes	Partial	Partial	No
Poston (2008)[123]	Yes	Partial	Partial	No
Morgan (2005)[145]	Yes	Clinical outcomes not reported	Partial	No
Boger (2010)[146]	Yes	Partial	Partial	No
Nazemi (2006)[115]	Yes	Partial	Partial	No
Prewitt (2008)[58]	Yes	Clinical outcomes not reported	Partial	No
Barnett (2010)[147]	Yes	Partial	Partial	Partial
Halliday (2010)[86]	Yes	Yes	Yes	Partial
Holtz (2010)[96]	Yes	Partial	Partial	No
Pasic (2010)[148]	Yes	Partial	Partial	No
Raju (2010)[149]	Yes	Partial	Partial	No
Wright (2010)[150]	Yes	Partial	Partial	No
Sarlos (2010)[151]	Yes	Partial	Partial	No
Bell (2008)[102]	Yes	Partial	Partial	No

Appendix 16: Treatment of Robotic Costs in Studies from Economic Review

Table A21: Treatment of Robotic Costs in Studies from Economic Review

Author	Robot Cost	Amortization Period of Robot	Annual Maintenance Cost	Disposables/ Consumables
Bolenz (2010)[139]	Not included	-	Not included	Included
Hohwü (2010)[140]	Inclusion unclear	-	Inclusion unclear	Inclusion unclear
Laungani (2010)[142]	Inclusion unclear	-	Inclusion unclear	Inclusion unclear
Bolenz (2010)[129]	Not included	-	Not included	Included
Lotan (2010)[143]	Not included	-	Not included	Included
Ollendorf (2009)[130]	Not included	-	Not included	Not included
Joseph (2008)[141]	Included	Not stated	Included	Included
Steinberg (2008)[131]	Analysis with and without robot cost	5 years	Included	Included
Mayer (2007)[132]	Not included	-	Included	Included
Mouraviev (2007)[133]	Not included	-	Not included	Not included
O'Malley (2007)[134]	Included	7 years	Included	Included
Burgess (2006)[135]	Inclusion unclear	-	Inclusion unclear	Inclusion unclear
Scales (2005)[136]	Included	7 years	Included	Included
Guru (2004)[137]	Analysis with and without robot cost	5 years	Included	Inclusion unclear
Lotan (2004)[138]	Analysis with and without robot cost	7 years	Included	Included
Bachinsky (2010)[144]	Inclusion unclear	-	Inclusion unclear	Inclusion unclear
Kam (2010)[119]	Not included	-	Not included	Included
Poston (2008)[123]	Analysis with and without robot cost	5 years	Included	Included
Morgan (2005)[145]	Analysis with and without robot cost	5 years	Included	Included
Boger (2010)[146]	Not included	-	Not included	Included
Nazemi (2006)[115]	Inclusion unclear	-	Inclusion unclear	Inclusion unclear
Prewitt (2008)[58]	Inclusion unclear	-	Inclusion unclear	Included
Barnett (2010)[147]	Included	7 years	Included	Included
Halliday (2010)[86]	Analysis with and without robot cost	7 years	Analysis with and without maintenance cost	Included
Holtz (2010)[96]	Not included	-	Not included	Included
Pasic (2010)[148]	Not included	-	Not included	Inclusion unclear
Raju (2010)[149]	Included	Not stated	Included	Included
Wright (2010)[150]	Inclusion unclear	-	Inclusion unclear	Inclusion unclear
Sarlos (2010)[151]	Not included	-	Not included	Included
Bell (2008)[102]	Included	5 years	Inclusion unclear	Inclusion unclear

Appendix 17: Evidence Tables for Economic Review

Table A22: Study Characteristics of Economic Studies					
Author / Year of Publication	**Indication**	**Intervention and Comparator(s)**	**Setting**	**Type of Economic Evaluation**	**Perspective**
Bolenz et al. (2010)[139]	Prostatectomy	Robotic-assisted laparoscopic prostatectomy versus laparoscopic prostatectomy and open retropubic prostatectomy	United States, inpatient	Cost-consequences	Hospital
Hohwü et al. (2010)[140]	Prostatectomy	Robotic-assisted laparoscopic prostatectomy versus open retropubic prostatectomy	Denmark, inpatient and outpatient	Cost-effectiveness and cost-utility	Unclear, possibly publicly-funded health care system
Laungani et al. (2010)[142]	Prostatectomy	Robotic-assisted laparoscopic prostatectomy versus open retropubic prostatectomy	United stated, inpatient	Costing	Hospital
Bolenz et al. (2010)[129]	Prostatectomy	Robotic-assisted laparoscopic prostatectomy versus laparoscopic prostatectomy and open retropubic prostatectomy	United States, inpatient	Costing	Hospital
Lotan et al. (2010)[143]	Prostatectomy	Robotic-assisted laparoscopic prostatectomy versus laparoscopic prostatectomy and open retropubic prostatectomy	United States, inpatient	Costing	Surgeon and hospital
Ollendorf et al. (2009)[130]	Prostatectomy	Robotic-assisted laparoscopic prostatectomy versus open radical prostatectomy	United States, inpatient and outpatient	Cost-utility	Societal
Joseph et al. (2008)[141]	Prostatectomy	Robotic-assisted prostatectomy versus laparoscopic prostatectomy and open retropubic	United States, inpatient	Cost-consequences	Hospital

Table A22: Study Characteristics of Economic Studies					
Author / Year of Publication	**Indication**	**Intervention and Comparator(s)**	**Setting**	**Type of Economic Evaluation**	**Perspective**
		prostatectomy			
Steinberg et al. (2008)[131]	Prostatectomy	Robotic-assisted radical prostatectomy versus laparoscopic radical prostatectomy	United States, inpatient	Cost-benefit	Hospital
Mayer et al. (2007)[132]	Prostatectomy	Robotic-assisted prostatectomy versus laparoscopic prostatectomy and open radical prostatectomy	United Kingdom, inpatient	Costing	Hospital
Mouraviev et al. (2007)[133]	Prostatectomy	Laparoscopic robotic prostatectomy versus cryosurgical ablation of the prostate, radical retropubic prostatectomy and radical perineal prostatectomy	United States, inpatient	Cost-consequences	Hospital for costs, patient outcomes up to post-30 days
O'Malley et al. (2007)[134]	Prostatectomy	Robotic-assisted laparoscopic radical prostatectomy versus open radical prostatectomy	Australia, inpatient and outpatient	Cost-utility	Societal
Burgess et al. (2006)[135]	Prostatectomy	Robotic-assisted laparoscopic prostatectomy versus radical retropubic prostatectomy and radical perineal prostatectomy	United States, inpatient	Costing	Hospital
Scales et al. (2005)[136]	Prostatectomy	Robotic-assisted prostatectomy versus radical retropubic prostatectomy	United States, inpatient	Costing	Hospital
Guru et al. (2004)[137]	Prostatectomy	Robotic-assisted laparoscopic versus open	United States, inpatient	Costing	Hospital

Table A22: Study Characteristics of Economic Studies					
Author / Year of Publication	**Indication**	**Intervention and Comparator(s)**	**Setting**	**Type of Economic Evaluation**	**Perspective**
		retropubic prostatectomy.			
Lotan et al. (2004)[138]	Prostatectomy	Laparoscopic and robotic-assisted prostatectomy versus open radical retropubic prostatectomy	United States, inpatient	Costing	Hospital
Bachinsky et al. (2010)[144]	Hybrid Coronary Artery Revascularization (HCR=CABG+ PCI)	Robotic assisted HCR versus OPCAB	United States, inpatient	Cost-consequences	Hospital
Kam et al. (2010)[119]	Mitral Valve Repair (MVr)	Robotic MVr versus conventional MVr	Australia, inpatient	Cost-consequences	Hospital
Poston et al. (2008)[123]	Coronary artery bypass grafting (CABG)	Mini-CABG using surgical robot versus OPCAB performed via a median sternotomy	United States, inpatient and outpatient	Cost-consequences	Hospital for treatment costs, patient outcomes (including return to work) evaluated up to one year post-surgery.
Morgan et al. (2005)[145]	Atrial septal defect (ASD) and mitral valve repair (MVr)	Robotic-assisted ASD and MVr versus conventional techniques (sternotomy)	United States, inpatient	Costing	Hospital
Boger et al. (2010)[146]	Nephrectomy	Robot-assisted nephrectomy versus laparoscopic nephrectomy and hand-assisted laparoscopic nephrectomy	United States, inpatient	Cost-consequences	Hospital
Nazemi et al. (2006)[115]	Nephrectomy	Robotic-assisted radical nephrectomy versus open surgery or laparoscopic surgery with or without hand-	United States, inpatient, outpatient	Cost-consequences	Hospital for costs, patient outcomes up to 31 months

Table A22: Study Characteristics of Economic Studies					
Author / Year of Publication	**Indication**	**Intervention and Comparator(s)**	**Setting**	**Type of Economic Evaluation**	**Perspective**
		assistance			
Prewitt et al. (2008)[58]	Prostatectomy, Nephrectomy, and Carotid arterial bypass	Robotic surgery versus open surgery	United States, inpatient	Costing	Hospital
Barnett et al. (2010)[147]	Hysterectomy	Robotic hysterectomy versus laparoscopic hysterectomy and laparotomy	United States, inpatient and community	Costing	Hospital and Societal
Halliday et al. (2010)[86]	Hysterectomy	Robotic hysterectomy versus laparotomy	Canada, inpatient	Cost-consequences	Health care system
Holtz et al. (2010)[96]	Hysterectomy	Robotic hysterectomy versus laparoscopic hysterectomy	United States, inpatient	Cost-consequences	Hospital
Pasic et al. (2010)[148]	Hysterectomy	Robotic hysterectomy versus laparoscopic hysterectomy	United States, inpatient and outpatient	Cost-consequences	Hospital
Raju et al. (2010)[149]	Hysterectomy	Robotic hysterectomy versus laparotomy, and laparoscopy	United Kingdom, inpatient	Cost-consequences	Hospital
Wright et al. (2010)[150]	Hysterectomy	Robotic hysterectomy versus laparotomy, and laparoscopy	United States, inpatient	Cost-consequences	Hospital
Sarlos et al. (2010)[151]	Hysterectomy	Robotic hysterectomy versus laparoscopic hysterectomy	Switzerland, inpatient	Cost-consequences	Hospital
Bell et al. (2008) [102]	Hysterectomy and lymphadenectomy in endometrial cancer	Robotic hysterectomy and lymphadenectomy versus laparotomy, and laparoscopy	United States, inpatient and outpatient	Cost-consequences	Societal

ASD=Atrial septal defect; CABG=coronary artery bypass graft; HCR=Hybrid coronary artery revascularization; mini-CABG=Minimally invasive coronary artery bypass grafting; MVr=mitral valve repair; OPCAB=off-pump coronary artery bypass; PCI=percutaneous coronary intervention.

Table A23: Additional Study Characteristics of Economic Studies						
Author / Year of Publication	**Clinical Data Sources**	**Economic Data Sources and Costs Included in Analysis**	**Treatment of Robotic Equipment Costs**	**Currency and Year for Cost Evaluation**	**Time Horizon**	**Sensitivity Analysis**
Bolenz et al. (2010)[139]	Retrospective analysis of records of single hospital	Billing department of single US hospital Direct costs: anesthesia (professional and nursing fees), radiology, operating room, surgical supplies, pathology, medication, laboratory, room and board	Purchase and maintenance cost of robot not included in analysis. Cost of disposables and consumables included.	US dollars, year not stated	Duration of hospital stay	Not conducted
Hohwü et al. (2010)[140]	Retrospective analysis of records of single hospital	Not stated	Not stated	Euros, year not stated	One year post-surgery	One-way sensitivity analysis, parameters not specified
Laungani et al. (2010)[142]	Retrospective analysis of records of single hospital	Billing of single US hospital Specific costs not described	Not stated	US dollars, year not stated	Duration of hospital stay	Not conducted
Bolenz et al. (2010)[129]	Retrospective analysis of records of single hospital	Billing of single US hospital Room and board, laboratory, medication, operating room, anesthesia, surgical supplies	Purchase and maintenance cost of robot not included in analysis. Cost of disposables and consumables included.	US dollars (2007)	Duration of hospital stay	Not conducted
Lotan et al. (2010)[143]	Retrospective analysis of	Single US hospital	Purchase and maintenance	US dollars, year not	Duration of	Not conducted

Table A23: Additional Study Characteristics of Economic Studies						
Author / Year of Publication	**Clinical Data Sources**	**Economic Data Sources and Costs Included in Analysis**	**Treatment of Robotic Equipment Costs**	**Currency and Year for Cost Evaluation**	**Time Horizon**	**Sensitivity Analysis**
	records of single hospital	billing department Hospital costs, patient payments, surgeon fees. Total hospital costs divided into direct and indirect costs, however respective definitions not provided	cost of robot not included in analysis. Cost of disposables and consumables included.	stated	hospital stay	
Ollendorf et al. (2009)[130]	Systematic review	Medicare Treatment costs, physician visits, biopsies, medication, patient time, short-term and long-term side-effects	Not included in analysis	US dollars (2008)	Lifetime, with future costs and QALYs discounted at rate of 3%	Not reported
Joseph et al. (2008)[141]	Case series of single hospital	Hospital database OR costs, including: OR supplies, OR time, nursing labour, ambulatory surgical centre, post anesthesia care unit, anesthesia supplies, anesthesia technical labour	Cost of robot and its maintenance included. Disposables and consumables included.	US dollars, year not stated	Duration of hospital stay	Not conducted
Steinberg et al. (2008)[131]	Not applicable	Billing of single US	Performed analysis	US dollars, year not	Duration of	One-way sensitivity

Table A23: Additional Study Characteristics of Economic Studies						
Author / Year of Publication	**Clinical Data Sources**	**Economic Data Sources and Costs Included in Analysis**	**Treatment of Robotic Equipment Costs**	**Currency and Year for Cost Evaluation**	**Time Horizon**	**Sensitivity Analysis**
		hospital Cost of robot, service contract, and disposables	under two scenarios: with purchase of robot and with donation of robot. Value of purchased robot amortized over 5 years. Service and disposables included	stated	hospital stay	analysis on profitability at different baseline caseloads
Mayer et al. (2007)[132]	Not reported	Sources not reported. Nursing, medical staff, robot service contract, hospital stay, consumables	Assumed robot was donated and accounted only annual service contract (£400 per procedure). Cost of disposables and consumables included.	British pounds, year not stated	Duration of hospital stay	Not conducted
Mouraviev et al. (2007)[133]	Records of single hospital	Single hospital. Total direct: Surgery, nursing, pharmacy, cardiac services, respiratory therapy, radiology, laboratory, transfusion services, supplies. Surgical costs included OR time, surgical supplies,	Cost of robot not included in analysis.	US dollars, year not stated	Duration of hospital stay for costs and LOS, >30 days for health outcomes	Not conducted

Table A23: Additional Study Characteristics of Economic Studies						
Author / Year of Publication	**Clinical Data Sources**	**Economic Data Sources and Costs Included in Analysis**	**Treatment of Robotic Equipment Costs**	**Currency and Year for Cost Evaluation**	**Time Horizon**	**Sensitivity Analysis**
		anesthesia, post-anesthesia care unit costs. Indirect hospital expenses				
O'Malley et al. (2007)[134]	Published data from single US hospital	Single Australian hospital billing records Fixed capital costs, robot maintenance costs, disposables and consumables, surgeon's fees, bed days, lost productivity	Robot was included in analysis, with assumption of 200 procedures in first year, to 500 procedures in years six and seven. Maintenance contract treated similarly. Disposables and consumables included in analysis	Australian dollars, year not stated	One year	Not conducted
Burgess et al. (2006)[135]	Records of single US hospital	Patient billing records from single hospital Total hospital charges, broken down into operative and non-operative charges	Inclusion of robot among costs unclear	US dollars, year not stated	Duration of hospital stay	Not conducted
Scales et al. (2005)[136]	Not reported	Single hospital administration records, Medicare fee schedules Operating	Robot and maintenance was amortized over seven years, with assumption of seven	US dollars, year not stated	Duration of hospital stay	One-way and two-way sensitivity analyses on robotic operative time, LOS,

Table A23: Additional Study Characteristics of Economic Studies						
Author / Year of Publication	**Clinical Data Sources**	**Economic Data Sources and Costs Included in Analysis**	**Treatment of Robotic Equipment Costs**	**Currency and Year for Cost Evaluation**	**Time Horizon**	**Sensitivity Analysis**
		room, consumable equipment, anesthesia, post-anesthesia care, transfusion, professional fees, costs of robot and maintenance contract, room and board, pharmacy, laboratory services.	cases per week (364 cases/year). Disposables and consumables included in analysis			case volume, and daily cost of hospitalizati on
Guru et al. (2004)[137]	Retrospective analysis of consecutive patients from single centre	Single hospital accounting system Anesthesia, laboratory, supplies, operating room, pharmacy, recovery room, ward care, robot and maintenance contract	Analysis done with and without cost of robot. Analysis with robot depreciates cost of equipment and maintenance over 5 years and assumes annual caseload of 300. Unclear if cost of disposables and consumables included.	US dollars, year not stated	Duration of hospital stay	Not conducted
Lotan et al. (2004)[138]	Literature search	Single hospital administration, Medicare reimbursement fees, literature search Operating	Analysis done under two scenarios: including cost and maintenance of robot, and assuming robot was	US dollars, year not stated	Duration of hospital stay	One-way and two-way sensitivity analyses including robot costs, case volume, LOS,

Table A23: Additional Study Characteristics of Economic Studies						
Author / Year of Publication	**Clinical Data Sources**	**Economic Data Sources and Costs Included in Analysis**	**Treatment of Robotic Equipment Costs**	**Currency and Year for Cost Evaluation**	**Time Horizon**	**Sensitivity Analysis**
		room costs, equipment, surgeon professional fees, hospital room and board, intravenous fluids and medication, robot and maintenance	donated and including cost of maintenance only. Cost of robot was amortized over seven years and assumes annual caseload of 300. Disposables and consumables included in analysis			operative time, and cost of laparoscopic equipment
Bachinsky et al. (2010)[144]	Prospective assessment of patients from single hospital	Not stated	Not stated	US dollars, year not stated	Thirty days post-surgery	Not conducted
Kam et al. (2010)[119]	Retrospective analysis of medical records from network of four hospitals.	Hospital network financial data. Operative costs: staffing, linen, supplies, anesthetic supplies, sterilizing services, perfusion, instruments, drapes, theatre supplies, pharmacy, suture items. Postoperative costs: ICU stay, cardiac ward stay, rehabilitation requirement	Cost of robot and its maintenance not included. Cost of disposables and consumables included.	Australian dollars (2007-8)	Duration of hospital stay	Not conducted

Table A23: Additional Study Characteristics of Economic Studies						
Author / Year of Publication	**Clinical Data Sources**	**Economic Data Sources and Costs Included in Analysis**	**Treatment of Robotic Equipment Costs**	**Currency and Year for Cost Evaluation**	**Time Horizon**	**Sensitivity Analysis**
Poston et al. (2008)[123]	Prospective observational study of patients undergoing revascularization at single US hospital	Single hospital database OR time, supplies including stent cost and robotic disposables, medications, labs, radiology, and other services, ICU, room, medications, labs, radiology, physical therapy, other tests, robot	Analysis done with and without cost of robot. Analysis with robot depreciates cost of equipment and maintenance over 5 years and assumes annual caseload of 100. Disposables and consumables included in analysis	US dollars, year not stated	Duration of hospital stay for costs, one year for patient outcomes	Not conducted
Morgan et al. (2005)[145]	Not reported	Single hospital database OR time, perfusion, supplies, medications, labs, respiratory services, ICU, room, medications, radiology, other tests, physical therapy, robot	Robot and maintenance was amortized over five years, with assumption of 100 cases per year. Disposables and consumables included in analysis	US dollars, year not stated	Duration of hospital stay	Not conducted
Boger et al. (2010)[146]	Retrospective analysis of single hospital records	Single hospital financial analysis Direct costs: surgical instruments, anesthetic, pharmaceuticals, nursing	Cost of robot and its maintenance not included. Cost of disposable surgical equipment included.	US dollars, year not stated	Duration of hospital stay	Not conducted

Table A23: Additional Study Characteristics of Economic Studies						
Author / Year of Publication	**Clinical Data Sources**	**Economic Data Sources and Costs Included in Analysis**	**Treatment of Robotic Equipment Costs**	**Currency and Year for Cost Evaluation**	**Time Horizon**	**Sensitivity Analysis**
		salaries, OR costs, recovery room costs. Indirect costs: overhead of hospital departments allocated to patient care.				
Nazemi et al. (2006)[115]	Retrospective analysis of single hospital database	Single hospital database Operating room charges and total hospital costs	Inclusion of robot among costs unclear	US dollars, year not stated	Duration of hospital stay for costs, up to 31 months for patient outcomes	Not conducted
Prewitt et al. (2008)[58]	Retrospective analysis of consecutive cases from single hospital centre	Costs of single hospital Operative procedure costs, hospital stay, staff salaries, procedure equipment, operating room staff, patient care supplies	Treatment of robot and its maintenance costs unclear. Disposables and consumables included in analysis	US dollars, year not stated	Duration of hospital stay	Not conducted
Barnett et al. (2010)[147]	Literature review	Single hospital accounting department, literature, Medicare schedules, BLS Preoperative holding costs, anesthesia and surgery professional	Robot was amortized over seven years at 5%, and assumed 324 cases per year (27 per month). Maintenance costs included. Disposable equipment included in	US dollars (2008)	Duration of hospitalization for hospital perspective, and up to 52 days post-discharge for societal perspective	One-way: case load, costs, LOS, OR time, surgical conversion rates, transfusion rates, time to return to normal daily activities, lost wages of patient

Table A23: Additional Study Characteristics of Economic Studies						
Author / Year of Publication	**Clinical Data Sources**	**Economic Data Sources and Costs Included in Analysis**	**Treatment of Robotic Equipment Costs**	**Currency and Year for Cost Evaluation**	**Time Horizon**	**Sensitivity Analysis**
		fees, OR time, OR anesthesia and set-up fees, robot, postoperative anesthesia care unit, room and board, transfusions, pharmacy, lost wages and caregiver costs	analysis			and caregiver, cost-to-charge ratio
Halliday et al. (2010)[86]	Retrospective chart review and prospective assessment of patients from single hospital	Facility costs, fee schedules Hospital stay, Surgeon fees, anesthetist fees, OR use and supplies, OR nursing and anesthesia, pharmacy, radiology, labs, readmission, robot costs and maintenance	Analysis done with and without robot and maintenance costs. Robot was amortized over seven years, and assumed 260 cases per year (5 per week). Service cost assumed to be 10% of purchase price of robot each year. Disposables and consumables included in analysis	Canadian dollars, year not stated	Duration of hospital stay with allowance for readmission	Two-way sensitivity analysis on case load and cost of robot
Holtz et al. (2010)[96]	Retrospective chart review at single hospital centre	Facility costs OR time, disposable robotic instruments, nursing care, anesthesia, pathology, radiology,	Cost of robot and its maintenance not included. Cost of disposables and consumables included	US dollars, year not stated	Duration of hospital stay	Not conducted

Table A23: Additional Study Characteristics of Economic Studies						
Author / Year of Publication	**Clinical Data Sources**	**Economic Data Sources and Costs Included in Analysis**	**Treatment of Robotic Equipment Costs**	**Currency and Year for Cost Evaluation**	**Time Horizon**	**Sensitivity Analysis**
		laboratory studies, phlebotomy, pharmacy, ancillary services				
Pasic et al. (2010)[148]	Premiere Hospital Database containing 36,188 cases from 358 hospitals	Premiere Hospital Database for inpatient and outpatient billing	Cost of robot and its maintenance not included. Inclusion of cost of disposables and consumables unclear	US dollars, year not stated	Up to 30 days post-discharge	Not conducted
Raju et al. (2010)[149]	Analysis of 16 robotically performed procedures from single hospital centre. Data on robotic procedures obtained prospectively, while those of laparoscopic and open procedures obtained retrospectively	National Health Service costs Robot costs (instruments, maintenance, depreciation), other surgical supplies, bed costs	Robot costs (instruments, maintenance, depreciation) included Caseload and amortization period and rate not stated	British Pounds, year not stated	Duration of hospital stay	Not conducted
Wright et al. (2010)[150]	Retrospective analysis of electronic medical records of consecutive patients from single hospital centre	Hospital billing data Specific costs not stated	Not stated	US dollars, year not stated	Duration of hospital stay	Not conducted
Sarlos et al. (2010)[151]	Case control study conducted at single hospital centre	Single hospital centre Personnel and surgical supplies	Cost of robot not included in analysis. Cost of disposables and consumables included.	Euros, year not stated	Duration of hospital stay	Not conducted

Table A23: Additional Study Characteristics of Economic Studies						
Author / Year of Publication	**Clinical Data Sources**	**Economic Data Sources and Costs Included in Analysis**	**Treatment of Robotic Equipment Costs**	**Currency and Year for Cost Evaluation**	**Time Horizon**	**Sensitivity Analysis**
Bell et al. (2008) [102]	Retrospective single hospital chart review	Single hospital business office, costing based on American Hospital Association standards Radiology, pharmacy, laboratory, supplies, surgery, recovery time, anesthesia, room and board, robot, estimated lost wages and household productivity.	Cost of robot and maintenance amortized over five years, however expected caseload not specified. Unclear if cost of disposables and consumables included	US dollars, year not stated	Duration of hospital stay for hospital costs and complica tions, <2 months for return to normal activities	Not conducted

BLS=Bureau of Labour Statistics; ICU=intensive care unit; LOS=length of stay; OR: operating room; US=United States; QALY=Quality-adjusted life-year

Table A24: Results of Economic Studies			
Author / Year of Publication	**Patient Characteristics**	**Clinical Outcomes/Benefits**	**Economic Outcomes**
Bolenz et al. (2010)[139]	Laparoscopic, BMI<30/BMI≥30: N: 151/60 Age (median, IQR): 59(54-63)/56.5(52-63) Pre-operative PSA, ng/mL: 5(4.2-6.5)/5.1(4-7.2) Prostate volume, mL: 46(40-58)/48(40-63) Open, BMI<30/BMI≥30: N:114/42 Age (median, IQR): 61.5(57-66)/60.5(54-64) Pre-operative PSA, ng/mL: 5.6(4.4-7.2)/4.7(4.1-5.9) Prostate volume, mL: 46.5(37-59)/43(34-60) Robotic, BMI<30/BMI≥30: N:191/71 Age (median, IQR): 62(56-66)/60(57-65) Pre-operative PSA, ng/mL: 5.2(4.1-7)/5.4(4.3-7) Prostate volume, mL: 46.5(36-60)/42(36-57.4) No statistically significant differences in patient characteristics with respect to BMI category	Laparoscopic, BMI<30/BMI≥30: LOS (median days, IQR): 2(1-2)/2(1-2) Biopsy, Gleason sum : ≤6: 84(55.6%)/31(54.4%) 7: 53 (35.1%)/22(38.6%) 8-10: 14(9.3%)/4(7.0%) Nerve sparing: 145 (96.7%)/56(93.3%) Transfusion (n,%): 4(2.7%)/0(0%) Open, BMI<30/BMI≥30: LOS (median days, IQR): 2(2-2)/2(2-3) Biopsy, Gleason sum: ≤6: 72(63.7%)/26(61.9%) 7: 33(29.2%)/10(23.8%) 8-10: 8(7.1%)/6(14.3%) Nerve sparing (n, %): 98 (89%)/36(90%) Transfusion (n,%): 20(18.5%)/12(28.6%) Robotic, BMI<30/BMI≥30: LOS (median days, IQR): 1(1-2)/1(1-2) Biopsy, Gleason sum: ≤6: 94 (49.2%)/34(47.9%) 7: 84(44%)/34(47.9%) 8-10: 13(6.8%)/3(4.2%) Nerve sparing (n, %): 145(85.3%)/47(85.4%) Transfusion (n,%): 11(5.8%)/1(1.4%) No statistically significant differences in clinical outcomes with respect to BMI	Median values and IQRs Laparoscopic, BMI<30/BMI≥30: OR service: $2,375($2,130-$2,769) /$2,639($2,343-$3,013), P=0.004 Anesthesia: $365($297-$411) /$401($322-$434), P=0.004 Medication: $268($203-$326) /$289($231-$342), P=0.04 Room and board: $990($495-$990) /$990($495-$990), P=0.30 Laboratory: $373($312-$543) /$406($335-$532), P=0.47 Blood bank: $0($0-$976) /$0($0-$129), 0.50 Respiratory services:$0($0-$638) /$0($0-$41), P=1.00 Total direct costs: $5,347($4,913-$5,727) /$5,703($5,143-$6,254), P=0.002 Open, BMI<30/BMI≥30: OR service: $1,593($1,383-$1,917) /$1,766($1,592-$2,271), P=0.01 Anesthesia: $234($189-$274) /$269($234-$334), P<0.001 Medication: $268($234-$319) /$303($231-$365), NS Room and board: $990($990-$990) /$990($990-$1,485), NS Laboratory: $648($415-$860) /$748($526-$894), NS Blood bank: $0($0-$902) /$0($0-$7,549), P=0.02 Respiratory services: $0($0-$0)/$0($0-$2,833), P<0.001 Total direct costs: $4,377($3,905-$4,981)/$4,885($4,089-$5,705), P=0.004 Robotic, BMI<30/BMI≥30: OR service:$2,793($2,459-$3,132)/$2,847($2,566-$3,378), NS Anesthesia: $418($376-$456) /$431($387-$480), P=0.04 Medication: $297($249-$353)/$297($239-$357), NS

Table A24: Results of Economic Studies			
Author / Year of Publication	**Patient Characteristics**	**Clinical Outcomes/Benefits**	**Economic Outcomes**
		category	Room and board: $495($495-$990)/$495($495-$990), NS Laboratory:$293($249-$347)/$299($242-$367), NS Blood bank: $0($0-$1,695)/ $0($0-$599), NS Respiratory services: $0($0-$785)/$0($0-$37), NS Total direct costs: $6,745($6,216-$7,369)/$6,761($6,354-$7,429), NS
Hohwü et al. (2010)[140]	Robotic/open N: 77/154 Age range: 50-69 (both groups)	Difference in between-group procedure success was 7% in favour of robotic surgery, where a successful procedure was defined as postoperative PSA<0.2ng/mL, preserved urinary continence, and erectile function. There were no QALY gains with RALP after one year.	ICER: €64,343 per treatment success using robotic surgery
Laungani et al. (2010)[142]	Not stated	Between 2004 (when prostatectomy was performed using open approach), and 2009 (when surgeries were performed using robot), LOS decreased from 2.72 days to 1.08 days	Initial average costs per case were $16,495 for open prostatectomy, and $25,593 for robotic prostatectomy. After two years, average cost of robotic prostatectomy had declined and was below that of open prostatectomy ($14,481).
Bolenz et al. (2010)[129]	Robotic/laparoscopic/open N: 262/220/161 Age (median): 61/59/61 BMI: 28/27/27 Preoperative PSA: 5.3/5.0/5.3 Prostate volume (cm^2): 46/46/45 Gleason score 8-10 (%):6.1/8.4/8.8	Robotic/laparoscopic/open LOS (median days): 1/2/2, P<0.0001 Nerve sparing (% procedures): 85/96/90, P<0.001 Lymphadenectomy (% procedures): 11/22/100, P<0.001 Blood transfusion (%procedures): 4.6/1.8/21.0, P=0.001	Robotic/laparoscopic/open Direct costs (median): $6,752/$5,687/$4,437, P<0.0001 OR service (median): $2798/$2453/$1611, P<0.0001 Surgical supply (median): $2015/$725/$185 Anesthesia (median): $419/$365/$234, P<0.0001 Medication (median): $297/$271/$272, P=0.0008 Room and board (median): $495/$990/$990, P<0.0001 Lab (median): $295/$386/$659, P<0.0001
Lotan et al. (2010)[143]	Open/laparoscopic/open N:157/214/246	Not provided	Open/laparoscopic/robotic Total costs, mean (range): $6,473 ($3,677-$16,490)/ $8,557($6,074-$13,239)/

Table A24: Results of Economic Studies			
Author / Year of Publication	**Patient Characteristics**	**Clinical Outcomes/Benefits**	**Economic Outcomes**
			$10,269($6,494-$40,401) Total payments, mean (range): $6,893($2,000-$17,820)/ $6,805($1,103-$20,431)/ $7,616($1,457-$27,210) Profit, mean (range): $419 (-$10,404- $11,663)/ -$1,752(-$9,433,$11,994)/ -$2,653(-$30,398-$17,900) Surgeon fee, mean (range): $2,250($1,298-$5,384)/ $2,662($1,080-$8,480)/ $3,007($1,422-$10,560) Amount of surgeon fee covered by insurance, mean (range): $1,992($745-$3,350)/ $2,173($641-$5,400)/ $2,154($671-$5,026)
Ollendorf et al. (2009)[130]	Basecase patient is 65 year-old male with clinically localized, low-risk prostate cancer	Robotic/open Mortality (%): 0.4%/0.4% Major complications: 2.5%/4.7% Minor complication: 5.3%/9.5% Positive margins (pT2): 10.5%/16.8% Positive margins (pT3): 35.4%/45.2% Urethral stricture: 1.3%/3.4% Urinary incontinence (acute): 28.9%/46.7% Urinary incontinence (long-term): 7.3%/12.7% Erectile dysfunction (acute): 59.1%/76.8% Erectile dysfunction (long-term): 26.3%/45.3%	Robotic/open QALYs, discounted: 7.98/7.82 Total costs, discounted: $26,608/$28,348 Robotic strategy was more effective and less costly, and no ICER was reported
Joseph et al. (2008)[141]	Robotic/laparoscopic/open N: 106/57/70 Age (mean years): 60.0/57.6/53.6 Preoperative PSA (mean):	LOS: Duration not stated for robotic surgery patients however all were discharged on postoperative day 1, and authors state that difference between robotic and laparoscopic surgery was significant (P<0.05). For	Robotic/laparoscopic/open Labour costs: $494/$832/$330 Supply costs: $4,805/$2,933/$1,429 Anesthetic supply costs:

Table A24: Results of Economic Studies			
Author / Year of Publication	**Patient Characteristics**	**Clinical Outcomes/Benefits**	**Economic Outcomes**
	6.6/8.4/7.2 Gleason score: 6/6/6	comparison of laparoscopic and open surgery, LOS was 25.4 hours and 64.5 hours, respectively (P=0.0003). Diet hours were higher in open surgery patients compared with laparoscopic surgery patients (39 vs. 8). Data on robotic surgery patients were not provided. Postoperative pain scores were reported for laparoscopic and open surgery only, and values were significantly higher in open surgery patients up to two days post-surgery.	\$111/\$111/\$111 Total OR costs: \$5,410/\$3,876/\$1,870
Steinberg et al. (2008)[131]	Not reported	Not reported and assumed that OR time, LOS, blood loss, and all oncological outcomes were the same in the robotic and laparoscopic groups.	Purchase of a robot reduces income by at least \$415,000 per year. If an institution maintains identical caseload when switching from laparoscopic to robotic surgery, it cannot maintain equivalent profits. Seventy-eight cases per year are needed to cover the cost of a purchased robot, while only 20 cases per year are needed if the robot is donated.
Mayer et al. (2007)[132]	Not reported	Not reported	Robotic/laparoscopic/open Total costs: £6,704.84/£4,755.75/£3,701.00
Mouraviev et al. (2007)[133]	Retropubic/perineal/robotic/CAP N:197/60/137/58 Age: 60±6/60±7/59±7/67±7, P<0.005 CAP versus other groups ASA Score: 2.2±0.4/2.2±0.4/2.1±0.3/2.5±0.5	Retropubic/perineal/robotic/CAP LOS (mean days) : 2.79±1.46/ 2.87±1.43/ 2.15±1.48/ 0.16±0.14, CAP P<0.005 Extracapsular extension (%): 19.3/14.9/13.7/-, P<0.0001 Seminal vesicle invasion (%): 7.6/9.0/2.2/-, P=0.0115 Gleason score >7 (%):	Retropubic/perineal/robotic/CAP Surgery (mean): \$2,471/\$2,788/\$3,441/\$5,702, P<0.05 Nursing (mean): \$1,013/\$1,104/\$752/\$110 Pharmacy (mean): \$593/\$578/\$570/\$199 Cardiac (mean): \$10/\$12/\$6/\$2 Respiratory (mean): \$24/\$30/\$20/\$0 Radiology (mean): \$55/\$64/\$45/\$17 Laboratory (mean): \$620/\$609/\$345/\$204

Table A24: Results of Economic Studies			
Author / Year of Publication	**Patient Characteristics**	**Clinical Outcomes/Benefits**	**Economic Outcomes**
		13.7/11.9/3.6/-, P<0.0001 positive margin (%): 20.3/25.4/30.2/-, P<0.0001 PSA recurrence (%): 9.6/10.4/8.6/-, P=0.0821	Transfusion (mean): $409/$158/$37/$0 Total Direct (mean): $5,259/$5,273/$5,386/$5,595, NS Grand Total (mean): $10,704/$10,536/$10,047/$9,195
O'Malley et al. (2007)[134]	Open/robotic N:100/500 Details on patient baseline clinical characteristics not reported	Open/robotic LOS (mean, days): 8/3 Incontinence (median, months): 5.26/1.47 Erectile dysfunction (median, months): 14.46/5.79	Open/robotic Fixed capital (mean): -/$1,501 Maintenance contract (mean): -/$809 Disposables and consumables (mean): -/$3,023 Surgeon fees (mean): $1,034/$1,034 Bed days (mean): $4,706/$1,637 Total (mean): $5,740/$8,004 Estimated incremental gain of 0.093 QALYs with robotic surgery over period of one year. Estimated ICER=$24,457.43/QALY.
Burgess et al. (2006)[135]	Robotic/retropubic/perineal N:78/16/16 Details on patient baseline characteristics not provided, however stated that patient demographics, clinical and pathological stage, and other pre-operative parameters were similar in the three groups	Robotic/retropubic/perineal Operative time, mean minutes (range): 262 (150-679)/ 202 (142-348)/ 196 (105-337), P=0.001 LOS, mean days (range): 1.2 (1-4)/1.7 (1-3)/1.0, P=0.397 Blood loss, mean mL (range): 227 (50-2,000)/ 1,015 (300-2,000)/ 780 (200-1,000), P<0.001	Robotic/retropubic/perineal Operative costs, mean (range): $25,443 ($17,367-$50,890)/ $16,522 ($13,000-$26,871)/ $16,320 ($10,940-$29,380), P=0.001 Nonoperative costs, mean (range): $13,872 ($9,671-$43,041)/ $14,663 ($10,075-$25,669)/ $13,451 ($8,091-$23,983), P>0.5 Total hospital costs, mean (range): $39,315 ($25,281-$81,263)/ $31,518 ($25,670-$40,495)/ $29,771 ($19,917-$41,463), P<0.001
Scales et al. (2005)[136]	Not reported	OR time and LOS estimated from the literature.	Retropubic specialist setting/retropubic community setting/robotic

Table A24: Results of Economic Studies			
Author / Year of Publication	**Patient Characteristics**	**Clinical Outcomes/Benefits**	**Economic Outcomes**
		Retropubic specialist setting/retropubic community setting/robotic OR time (minutes), mean: 160/160/140 LOS (days), mean: 2.5/3.2/1.3	Operating room: $2,316/$2,316/$2,183 Equipment: $575/$575/$1,704 Robot cost/case: $0/$0/$736 Anesthesia technical: $620/$620/$578 Post-anesthesia: $419/$419/$295 Professional fees: $1,787/$1,787/$2,173 Hospital room & board: $2,100/$2,688/$1,092 Pharmacy/transfusion/laboratory: $329/$329/$168 Total: $8,146/$8,734/$8,929
Guru et al. (2004)[137]	Robotic/open N:30/30 Groups comparable in their demographics, body mass index, operative time, and pathology, however details not provided	Robotic/open LOS (mean days): 1.07/2.4	Percent difference in robotic costs compared with open prostatectomy costs Anesthesia: 1.67% higher, P=0.5992 Laboratory: 37.30% higher, P<0.0001 Supplies: 171.98% higher, P<0.0001 Operating room: 3.96% lower, P=0.3727 Pharmacy: 64.90% lower, P<0.0001 Recovery room: 41.40% lower, P<0.0001 Ward care, 50.00% lower, P<0.0001 Total costs: 2.39% lower, P=NS
Lotan et al. (2004)[138]	Not reported	OR time and LOS estimated from the literature. Open/laparoscopic/robotic Operating room time (minutes), mean: 160/200/140 LOS (days), mean: 2.5/1.3/1.2	Open/laparoscopic/robotic with robot purchase/robotic with robot donated Total: $5,554/$6,041/$7,280/$6,709 OR: $2,428/$2,876/$2,204/$2,204 Equipment: $75/$533/$1,705/$1,705 Surgeon fees: $1,594/$1,688/$1,688/$1,688 Hospital room & board:

Table A24: Results of Economic Studies			
Author / Year of Publication	**Patient Characteristics**	**Clinical Outcomes/Benefits**	**Economic Outcomes**
			$988/$514/$474/$474 IV fluids & medications: $150/$78/$72/$72 Robot cost per case: -/-/$857/$286
Bachinsky et al. (2010)[144]	Robotic HCR/OPCAB N: 18/26 Baseline Syntax Score (CAD severity): 34.5±8.8/35.5±8.5	Robotic HCR/OPCAB Complete revascularization: 86%/76% (NS) Postoperative Day 1 Troponin: 0.80±0.06/2.3±2.6 (P=0.05) Extubated in OR: 79%/19% (P=0.001) ICU time (hours): 27.2±11.1/61.9±94.9 (NS) LOS (days): 4.6±2.4/8.2±5.9 (P=0.04) Blood transfusion: 7%/57% (P=0.004) Blood units transfused: 0.2±0.8/1.9±1.8 (P=0.011) Pain and patient satisfaction scores were higher in the robotic HCR group (data not shown). No differences in death, MI, or revascularization rates at 30 days post-surgery.	Robotic HCR/OPCAB Total hospital costs: $33,401/$28,476 (NS) Postoperative costs were lower in robotic HCR (data not shown).
Kam et al. (2010)[119]	Conventional MVR/Robotic MVR N: 40/107 Age: 61.6±11.16/57.6±13.67 (NS) Male: 82.5%/71.0% (NS) Pre-operative mitral regurgitation severity: Moderate-Severe:	Conventional MVR/Robotic MVR Total procedure time (min): 201.76/238.63 (P<0.001) Cardio-pulmonary bypass time (min): 93.72/126.37 (P<0.0001) Aortic cross-clamp time (min): 73.14/94.93 (P<0.001)	Conventional MVR/Robotic MVR Operative costs: $9,755.18/$12,328.70 Postoperative costs: $8,124.62/$6,174.79 Total hospital costs: $17,879.80/$18,503.49

Table A24: Results of Economic Studies			
Author / Year of Publication	**Patient Characteristics**	**Clinical Outcomes/Benefits**	**Economic Outcomes**
	17.5%/5.8% Severe: 82.5%/94.2% (P=0.029) Mitral valve pathology: Posterior leaflet: 84.8%/72.3% Anterior: 2.6%/6.9% Bileaflet: 12.8%/18.8% (NS) Hypertension: 38.5%/30.2% (NS) Diabetes Mellitus: 2.6%/0.9% (NS) Peripheral Vascular Disease: 0.0%/0.0% Prior MI: 0.0%/0.9% (NS) Prior CABG: 0.0%/0.0% Prior CVA:5.1%/3.8% (NS)	Ventilation time (hours): 6.61/6.17 (NS) ICU stay (hours): 45.46/36.66 (P=0.002) LOS (days): 8.76/6.47 (P<0.001) Post-pump regurgitation: None: 82.1%/82.1% Trace/trivial: 17.9%/14.2% Mild: 0%/2.8% Mild-moderate: 0%/0.9% (NS) Operative deaths:0/0 Postoperative bleeding: 0/2 Re-operations: 0/2 Required in-patient rehabilitation: 4/5 (NS)	
Poston et al. (2008)[123]	mini-CABG/OPCAB N: 100/100 Age (mean±SD, yrs) 61.8±9.4/ 66.2±10.1 Gender (% male): 72.0%/63.3% BMI (mean±SD): 29.9±9.7/28.4±6.7 Risk factors Current smoker: 29%/33% Family history of CAD: 40%/40% Diabetes: 32%/43% Dyslipidemia: 76%/86% Hypertension: 80%/80% Comorbidities Chronic lung disease: 14%/10% PVD: 28%/26%	mini-CABG/OPCAB Length of surgery (mean±SD, hours): 5.8±1.2/ 4.1±0.9, P<0.001 Hospital LOS (mean±SD, days): 3.77±1.51/6.38±2.23, P<0.001 ICU LOS (mean±SD, hours): 21.9±9.3/50.6±27.3, P<0.001 Intubation time (mean±SD, hours): 4.80±6.35/12.24±6.24, P<0.001 Intraoperative blood loss (mean±SD, mL): 547±366/1230±945, P=0.001 Packed red blood cell transfusion (mean±SD, units): 0.16±0.37/1.37±1.35, P<0.001 Major complications, no. patients (%): 12 (12%)/37 (37%), P=0.031 Atrial fibrillation, no. patients:	mini-CABG/OPCAB Intraoperative costs (mean±SD) Drugs: $201±$80/$164±$121, P=NS Supplies: $10,606±$3,073/$6,933±$2,152, P=0.016 Labs: $411±$146/$416±$73, P=NS OR time: $3,161±$606/$1,765±$499, P=0.004 Radiology: $952±$573/$68±$51, P<0.001 Other services: $358±$330/$474±$258, P=NS Total: $4,890±$3,211/$9,819±$2,229, P<0.001 Postoperative costs (mean±SD) Drugs: $304±$168/$503±$221, P=0.002 Labs: $95±$58/$140±$60,

Table A24: Results of Economic Studies			
Author / Year of Publication	**Patient Characteristics**	**Clinical Outcomes/Benefits**	**Economic Outcomes**
	Renal failure: 4%/0% Mean LVEF(%) Good: 52%/50% Moderate: 28%/27% Poor: 20%/23% History of CV disease No. diseased vessels (mean±SD): 2.8±0.5/2.8±0.4 Left main disease: 47%/43% Previous MI: 48%/56% CHF: 13%/26% Preoperative medications Beta blocker: 84%/80% ACE inhibitor: 36%/46% Aspirin: 88%/ 86% Statin: 82%/80% Logistic EuroSCORE (mean±SD): 10.5±18.1/10.7±11.9 Approximately 19.5% of all patients were categorized by All-Patient Refined Diagnosis-Related Group (APR-DRG) as being in the extreme class IV mortality risk, with an average EuroSCORE of 15.7 (The EuroSCORE predicts risk of operative mortality in patients undergoing cardiac surgery). The remaining 80.5% patients were APR-DRG Classes I-III, with an average EuroSCORE of 4.9. There were no between-group differences in risk of mortality.	12/20, P=NS 30-day readmittance, no. patients: 4/9, P=NS 1-Year Outcomes: MACCE: 4%/26%, HR=3.9, 95%CI: 1.4-7.6; P=0.0008 Satisfaction level with surgery =6 (highest): 76.5%/42.9%, P=0.035 Duration of postoperative incisional pain (mean±SD, days): 13.1±10.9/26.6±31.4, P=NS Return to work or normal activities (mean±SD, days): 44.2±33.1/93.0±42.5, P=0.016	P=0.026 Radiology: $201±$295/$180±$95, P=NS Non-ICU: $626±$473/$594±$761, P=NS ICU: $2,119±$1,014/$4,287±$1,345, P<0.001 Physical therapy: $183±$111/$233±$68, P=NS Other tests: $213±$237/$425±$538, P=NS Total: $3,741±$1,214/$6,361±$1,656, P<0.001 Total hospital costs: $18,631±$3,450/$16,180±$2,777, P=NS + Cost of Robot: $23,398±$3,333/$16,180±$2,777, P=0.001
Morgan et al. (2005)[145]	<u>Sternotomy ASD/robotic ASD</u> N: 10/10 Age (mean±SD, years): 42.0±13.3/46.6±10.5 Gender (% male): 40%/40% Prior MI (% patients): 0%/0% Prior CABG (% patients): 0%/0% Ejection fraction (mean±SD): 56.6±6.5/59.2±5.3 Hypertension (% patients):	<u>Sternotomy ASD/robotic ASD</u> LOS: 7.3±6.4/4.3±1.0, P=0.203 <u>Sternotomy MVr/ robotic MVr</u> LOS: 7.5±84.8/5.3±1.2, P=0.124	<u>Sternotomy ASD/robotic ASD</u> Intraoperative (mean±SD): $7,413±$2,581/$8,457±$2,623, P=0.409 Postoperative (mean±SD): $3,237±$876/ $3,164±$656, P=0.847 Total (mean±SD): $10,650±$2,991/$11,622±$3,231, P=0.518

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Author / Year of Publication	**Patient Characteristics**	**Clinical Outcomes/Benefits**	**Economic Outcomes**
	40%/40% Diabetes (% patients): 0%/0% PVD (% patients): 0%/0% Cerebrovascular accident (% patients): 30%/40% Cigarettes (% patients): 10%/0% <u>Sternotomy MVr/ robotic MVr</u> N: 10/10 Age (mean±SD, years): 59.8±17.5/52.8±11.2 Gender (% male): 30%/80% Prior MI (% patients): 30%/10% Prior CABG (% patients): 10%/0% Ejection fraction (mean±SD): 46.7±15.4/57.9±6.4 Hypertension (% patients): 60%/20% Diabetes (% patients): 10%/0% PVD (% patients): 0%/10% Cerebrovascular accident (% patients): 10%/0% Cigarettes (% patients): 30%/10%		Addition of the cost of the robot increased the average cost per case in the robotic ASD group by $3,773 (P=0.021) <u>Sternotomy MVr/robotic MVr</u> Intraoperative (mean±SD): $9,507±$1,598/$10,999±$1,186, P=0.029 Postoperative (mean±SD): $4,387±$1,690/$3,539±$839, P=0.173 Total (mean±SD): $13,894±$2,774/$14,538±$1,697 , P=0.539 Addition of the cost of the robot increased the average cost per case in the robotic MVr group by $3,444 (P=0.004) While differences in cost-drivers were not statistically significantly different, OR time and supplies (disposables) were higher in the robotics group perioperatively, and ICU stay and room fees were higher in the sternotomy groups postoperatively .
Boger et al. (2010)[146]	Laparoscopic/hand-assisted laparoscopic/ robotic N:46/20/13 Male (n): 24/11/8 Side: Left:23/6/9 Right:22/9/4 Bilateral: 1/5/- BMI (mean): 29/30/29 Preoperative Creatinine (mg/dL): 1.2/1.5/1.0 Diagnosis: Renal mass: 35/7/11 ADPKD: 2/13/- Non-functioning symptomatic renal unit: 9/-/2	Laparoscopic/hand-assisted laparoscopic/ robotic Estimated blood loss (mL, (median): 100/100/100, P=0.695 OR time (minutes, median): 171/210/168, P=0.060 LOS (days, median): 2.0/3.0/2.0, P=0.233 Morphine equivalents (mg., median): 33/45/30 Complications (n): 3/2/4	Laparoscopic/hand-assisted laparoscopic/ robotic Mean direct costs: $5,500/$6,979/$6,869 Mean total costs: $10,635/$12,823/$11,615

Table A24: Results of Economic Studies			
Author / Year of Publication	**Patient Characteristics**	**Clinical Outcomes/Benefits**	**Economic Outcomes**
	Renal mass size (cm): 5.8/7.2/4.8		
Nazemi et al. (2006)[115]	Open/robotic/hand-assisted laparoscopy/laparoscopy N:18/6/21/12 Age (years), median (range): 57 (38-98)/ 67.5 (44-78)/ 62 (27-81)/ 69 (43-76), P=0.59 Gender (% male): 83%/83%/71%/75%, P=0.83 BMI, median (range): 28.2 (15.9-50.3)/ 27.6 (20.9-32.9)/ 29.2 (22.3-46.9)/ 27.5 (19.2-39.8), P=0.83 Final pathological diagnosis: Malignant: 14 (78%)/5 (83%)/15 (71%)/8 (67%) Oncocytoma: 0/0/1 (5%)/2 (17%) Benign: 4 (22%)/1 (17%)/5 (24%)/2 (17%), P=0.76 Specimen size (cm),median (range): 15 (8-25)/ 12 (10-18)/ 15 (8-25)/ 14.5 (7-23), P=0.66 Tumour size (cm), median (range): 5.35 (1.8-15)/ 4.5 (2.8-5.5)/ 4.25 (1.5-15)/ 3.95 (2.3-15.0), P=0.94 Incidence of malignancy (renal cell cancer): 14 (78%)/5 (83%)/15 (71%)/8 (67%), P=0.87	Open/robotic/hand-assisted laparoscopy/laparoscopy Operative time (minutes), median (range): 202 (116-382)/ 345 (246-548)/ 265 (129-402)/ 237.5 (181-434), P=0.02 Est. blood loss (mL), median (range): 500 (75-3000)/ 125 (25-1500)/ 100 (10-1000)/ 125 (501-300), P=0.01 Postoperative change in creatinine (mg/dL), median (range): 0.15 (-1.0-2.9)/ 0.3 (-0.4-0.8)/ 0.4 (0.0-3.8)/ 0.4 (0.1-0.8), P=0.11 Postoperative drop in Hgb (g/dL), median (range): -2.1 (-7.4-0.5)/ -1.4 (-3.5-0.1)/ -1.7 (-4.2-1.1)/ -2.3 (-3.5-0.6), P=0.30 Blood transfusion: 3 (16%)/1 (16%)/5 (24%)/2 (17%), P=0.9 Postoperative analgesia: PCA pump: 6 (75%)/0/3 (14%)/2 (17%) Other: 2 (25%)/6 (100%)/18 (86%)/10 (83%), P=0.0035 Postoperative morphine equivalent use for analgesia (mg), median (range): 5.5 (1-10)/ 19.0 (2-212)/	Open/robotic/hand-assisted laparoscopy/laparoscopy OR costs (mean): $4,533/ $10,252/ $8,432/ $7,781, P=0.007 Total hospital costs (mean): $25,503/ $35,756/ $30,417/ $30,293, P=0.36

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Author / Year of Publication	**Patient Characteristics**	**Clinical Outcomes/Benefits**	**Economic Outcomes**
	Stage (TNM staging 1997 AJCC): T1a:3/2/7/3 T1b:4/2/3/1 T2:3/-/3/1 T3a:3/-/2/1 T3b:-/-/-/1 T4:-/-/-/1 T3a MI:1/1/-/-, P=0.70 Fuhrman Grade 1: 1(9%)/0/3 (25%)/0 2: 7(64%)/3 (60%)/7 (58%)/7 (87%) 3-4: 3(27%)/2 (40%)/2 (17%)/1 (13%), P=0.63 Follow-up (months), median (range) 15 (1-31)/4 (1-10)/5 (1-25)/7 (1-21), P=0.07 Disease recurrence 2/0/0/0, P=0.24	16 (0-210)/ 30 (0-58), P=0.37 Hospital stay (days), median (range) 5 (3-11)/3 (2-5)/4 (1-61)/4 (3-12), P=0.03 Perioperative complication rate 3 (17%)/1 (18%)/4 (19%)/2 (17%), P=1.00	
Prewitt et al. (2008)[58]	Open/ Robotic Prostatectomy, N=100/61 Nephrectomy, N=524/13 Carotid arterial bypass, N=1,207/12	Open/ Robotic LOS: Prostatectomy: 4.32/2.57 Nephrectomy: 5.58/2.85 Carotid arterial bypass: 8.74/4.33	Open/ Robotic Average direct costs: Prostatectomy: $5,911/$9,579 Nephrectomy: $12,359/$11,557 Carotid arterial bypass: $19,026/$14,160
Barnett et al. (2010)[147]	Not stated	Laparoscopic/Robotic/Open (Estimates obtained from literature review) Operative time (min): 213/192/147 Conversion risk (%): 4.9/2.9/Not applicable Transfusion risk (%): 2.5/1/1.5 LOS (days): 1.2/1.0/4/4 Return to daily activities (days): 31.6/24.1/52.0	Laparoscopic/Robotic/Open Preoperative holding: $95/$95/$95 Anesthesia professional fee: $1,385/$1,200/$923 Surgeon fee: $1,351/$1,351/$1,186 OR time: $2,326/$2,094/$1,600 Anesthesia set up fee: $341/$341/$341 OR set up fee: $1,085/$1,085/$1,381 Disposable instruments: $1,138/$2,210/$198

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Author / Year of Publication	**Patient Characteristics**	**Clinical Outcomes/Benefits**	**Economic Outcomes**
			Robot capital and maintenance: $1,292 Post-Op anesthesia care unit: $216/$216/$404 Room and board, transfusions, and pharmacy: $704/$515/$4,044 Lost wages and caregiver costs: $2,677/$2,045/$4,405 Total average costs: Hospital perspective: $6,581/$8770/$7,009 Hospital perspective without robot capital and maintenance costs: $6,581/$7,478/$7,009 Societal perspective: $10,128/$11,476/$12,847
Halliday et al.(2010)[86]	Open/Robotic N: 24/16 Age (mean±SD): 47±12/49±10 BMI (mean±SD): 25±5/26±6 Parity (mean±SD): 2±1/2±2 Gravidity (mean±SD): 2±2/3±2 No. patients with major comorbidities: 11(46%)/7(44%) Smokers: 10(42%)/5(31%) ASA Score (mean±SD): 2±1/2±1 No. prior abdominopelvic surgeries: 0:14(58%)/6(38%) 1: 5(21%)/8(50%) 2: 4(17%)/2(13%) ≥3: 1(4%)/0(0%) Stage Ia1: 2(8%)/1(6.3%) Ia2: 1(4%)/2(12.5%) Ib1: 18(75%)/8(50%) Ib2: 2(8%)/3(18.8%) IIa: 1(4%)/2(12.5%) Grade	Open/Robotic Type of hysterectomy: Type II: 5(21%)/1(6%) (NS) Type III: (19(79%)/15(94%) (NS) Surgical time (min): 283±63/351±51 (P=0.0001) Blood loss (mL): 546±570/106±113 (P<0.0001) Uterine weight (gr): 121±73/155±81 (P=0.06) Uterine volume (mL): 89±102/120±91 (P<0.05) Lymph node count (mean): 13±5/15±5 (NS) Opioid use: None:0 /3(19%) (NS) ≤1 day:1(4%)/8(50%) (P=0.0026) 2 days:7(29%)/5(31%) (NS) ≥3 days: 16(67%)/0(0%) (P=0.0001) Time to diet (mean days): 3.5±1.9/1.2±0.4 (P<0.0001) LOS (mean days): 7.2±5.3/1.9±0.9 (P<0.0001)	Open/Robotic Hospital accommodation: $9,044±$6,674/$2,445±$1,077 (P=0.0004) Surgeon fees: $1,214/$1,356 Anesthetist fees: $863±$190/$868±$135 (NS) Theatre costs: OR use and supplies (per case): $220/$2,977 Nursing: $208±45/257±32 (P=0.0007) Anesthesia: 199±43/245±31 (P=0.0007) Pharmacy: 104±180/10±8 (P=0.0440) Radiology: 95±201/0.6±2.2 (NS) Labs: 138±163/39±22 (P=0.004) Readmission: One case in Open group at cost of $3,787.50 Robot amortization costs: $1,429.70 per case

Table A24: Results of Economic Studies			
Author / Year of Publication	**Patient Characteristics**	**Clinical Outcomes/Benefits**	**Economic Outcomes**
	1: 3(13%)/6(38%) 2: 10(42%)/6(38%) 3: 11(46%)/4(24%) Histological subtype SCC: 18(75%)/10(63%) Non-SCC: 6(25%)/6(37%)	Adjuvant treatment: 6(25%)/8(50%) (NS) No. patients with complications: Major: 2/0 (NS) Minor: 15(63%)/3(19%) (P=0.003)	Total costs: $11,764±$6,790/$9,613±$1,089 (NS)
Holtz et al. (2010)[96]	Robotic/Laparoscopic N:13/20 Age (mean±SD): 63.5±11.3/63.3±11.2 (NS) BMI (mean±SD): 35.3±10.7/27.8±7.1 (P=0.04) Diabetes mellitus: 3/1 (NS) Hypertension: 7/10 (NS) Smoker: 2/0 (NS) Stage: IA:3/7 IB:5/5 IC:4/5 IIA:1/0 IIB:0/2 IIIA:0/1 (NS) FIGO Grade: 1:6/14 2:3/1 3:4/4 (NS)	Robotic/Laparoscopic Surgery time: 192.5±38/156.2±49 (P=0.03) Est. blood loss (ml): 84.6±32/150±111 (P=0.02) Uterine weight (g): 119±54/109±54 (NS) No. pelvic nodes: 10.4±4.5/6.4±5.4 (P=0.03) No. para-aortic nodes: 2.6±2.0/2.1±3.4 (NS) Conversion to laparotomy: 0/2 (NS) LOS (days): 1.7±0.6/1.7±1.2 (NS) Change in hemoglobin (g/dL): 2.3±1.5/2.1±0.8 (NS) Complications: 2/3	Robotic/Laparoscopic Total hospital costs: $5,084±$938/$3,615±$1,026 Average operative costs: $3,323±$601/$2,050±$536 Disposable instrumentation: $1,578±$442/$695±$273 OR time costs: $1,549±$190/$1,335±$335
Pasic et al. (2010)[148]	Robotic (inpatient,outpatient)/ Laparoscopic (inpatient, outpatient) N:(1282, 379)/(25789, 8738) Age (mean±SD): (48.84±12.29, 45.12±10.31) /(45.37±10.59, 43.76±8.67) Complex (n=7640) Large uterus: (0%,11%)/ (0%,9%) Malignancy: (21%,7%)/ (7%,3%) Adhesions: (11%,18%)/ (12%,11%) Non-complex (n=28548) (68%,65%)/ (80%,77%)	Robotic/Laparoscopic Complications (inpatient): Cardiac: 0.39%/0.26% (NS) Genitourinary: 11.93%/12.76% (NS) Gastrointestinal: 6.74%/7.48% (NS) Hemorrhage: 5.07%/5.88% (NS) Post-surgical infection: 7.49%/5.22% (P<0.01) Neurological: 0.08%/0.05% (NS) Pulmonary: 1.87%/1.07% (P<0.01) Wound: 0.23%/0.17% (NS) Vascular/thromboembolic: 0.78%/0.32% (P<0.01)	Robotic/Laparoscopic Adjusted hospital costs Inpatient: $9,640±$1,640/$6,973±$1,167 Outpatient: $7,920±$1,082/$5,949±$812

Table A24: Results of Economic Studies			
Author / Year of Publication	**Patient Characteristics**	**Clinical Outcomes/Benefits**	**Economic Outcomes**
	Illness severity (inpatient) APR-DRG Level 1&2: 98%/99% APR-DRG Level 3&4: 2%/1%	Complications (outpatient): Cardiac: 0.26%/0.05% (NS) Genitourinary: 19.26%/11.80% (P<0.01) Gastrointestinal: 7.12%/6.42% (NS) Hemorrhage: 3.96%/2.66% (NS) Post-surgical infection: 7.39%/5.41% (NS) Neurological: 0.26%/0.01% (P<0.01) Pulmonary: 0.26%/0.27% (NS) Wound: 0.25%/0.08% (0.24) Vascular/thromboembolic: 0.26%/0.31% (NS) Surgery time (hours): Inpatient: 3.22±0.52/2.82±0.46 Outpatient: 2.99±0.48/2.46±0.40 Inpatient LOS (days): 1.37±0.18/1.49±0.20 Surgery time and LOS were adjusted estimates	
Raju et al. (2010)[149]	Robotic surgery patients only Age: 53 (range:32-63) All patients referred to gynecology oncology clinic	Robotic surgery patients only Operating time (minutes): 120 (range108-220) Estimated blood loss (mL.) 30 (range: 20-75) LOS: 1 day Return to work: 2-3 weeks	Robotic/Laparoscopic/Open Robot use: £1,385/£0/£0 Other surgical supplies and equipment: £855.20/£823.20/£178.15 Bed costs: £500/£1,500/£2,500 Total costs: £2,740.20/£2,323.20/£2,678.15
Wright et al. (2010)[150]	Open/laparoscopic/robotic N: 385/481/63 Age range: 18-91 (all patients)	Open/laparoscopic/robotic Intraoperative complications: 7.8%/2.1%/1.6% Operative time (minutes): 196/188/267 LOS (days): 3.35/1.03/1.35	Open/laparoscopic/robotic Operative costs: $33,458/$34,047/$46,183 Total costs: $48,720/$41,436/$50,758 Multivariate linear regression analysis confirmed the significant independent effect of method of

Table A24: Results of Economic Studies			
Author / Year of Publication	**Patient Characteristics**	**Clinical Outcomes/Benefits**	**Economic Outcomes**
			hysterectomy on LOS, complication rate, operative costs, and total costs. BMI was found to be the most important predictor of operative time and operative costs regardless of surgical approach.
Sarlos et al. (2010)[151]	Laparoscopy/robotic N: 40/40 Age (years), mean (range): 43.6 (33-58)/47 (34-68), P=0.112 BMI, mean (range): 26 (19-38)/26 (19-46), P=0.288	Laparoscopy/robotic Operative time (min), mean (range): 82.9 (95-165)/108.9 (50-180), P<0.001 Hospital stay (days), mean (range): 3.9 (2-7) / 3.3 (2-6), P=0.924 Postoperative fever : 0/4 Urinary tract infection: 0/1 Wound infection: 1/0	Laparoscopy/robotic Material costs: €821.68/€2,295.08 Personnel costs, mean (range) : €1329 (1160-1707)/€ 1771 (1194-2288), P>0.05 Total cost of surgery, mean (range): €2151/€4067, P<0.05
Bell et al. (2008) [102]	Laparotomy/laparoscopy/robotic P-values for comparisons versus robotic surgery N: 40/30/40 Age (years) mean±SD: 72.3±12.5, P=0.0005/ 68.4±11.9, P=0.03/ 63.0±10.1 BMI, mean±SD: 31.8±7.7, P=0.54/ 31.9±9.8, P=0.59/ 33.0±8.5 Uterine weight (gr), mean±SD 155.6±134.8, P=0.41/ 138.5±75.5, P=0.87/ 135.9±72.8	Laparotomy/laparoscopy/robotic P-values for comparisons versus robotic surgery Operative time (min), mean±SD: 108.6±41.4, P=0.0001/ 171.1±36.2, P=0.14/ 184.0±41.3 Estimated blood loss (cc), mean±SD: 316.8±282.1, P=0.01/ 253.0±427.7, P=0.25/ 166.0±225.9 Number of nodes, mean±SD: 14.9±4.8, P=0.15/ 17.1±7.1, P=0.95/ 17.0±7.8 LOS (days), mean±SD: 4.0±1.5, P=0.0001/ 2.0±1.2, P=0.60/ 2.3±1.3	Laparotomy/laparoscopy/robotic P-values for comparisons versus robotic surgery Total average direct costs: $7,403.80±$3,310.60, P=0.15/ $5,564.00±$1,297.90, P=0.26/ $6,002.10±$733.9 Direct costs consisted of radiology, pharmacy, lab, supplies, surgical, recovery unit time, anesthesia, and room and board. Greatest differences in average direct costs seen in pharmacy, supplies, and room and board Total average indirect (overhead) costs: $5,539.80±$2,589.30, P=0.0001/ $2,005.80±$249.0, P=0.06/ $2,209.90±$417.7 Lost wages and household productivity $7,540.00/$4,582.00/$3,495.00

Table A24: Results of Economic Studies			
Author / Year of Publication	**Patient Characteristics**	**Clinical Outcomes/Benefits**	**Economic Outcomes**
		Return to normal activity (days), mean±SD: 52.0±71.8, P<0.0001/ 31.6±11.2, P=0.005/ 24.1±6.9 Total complications: 11 (27.5%), P=0.015/ 8 (20%), P=0.03/ 3 (7.5%) Transfusion: 6 (15%), P=0.10/ 3 (10%), P=0.40/ 2 (5%)	

ACE=angiotensin converting enzyme; ADPKD=autosomal dominant polycystic kidney disease; AJCC=American Joint Committee on Cancer; APR-DRG=All patient refined diagnosis related group; ASA=American Society of Anesthesiologists; ASD=atrial septal defect; BMI=Body Mass Index; CABG=Coronary artery bypass graft; CAD=coronary artery disease; CAP=cryosurgical ablation of the prostate; CHF=congestive heart failure; CV=cardiovascular; CVA: cerebrovascular accident; dL=decilitre; FIGO=International Federation of Gynecology and Obstetrics; HCR=Hybrid coronary artery revascularization ; Hgb=hemoglobin; ICER=incremental cost-effectiveness ratio; IQR=inter-quartile range;LOS=length of stay; LVEF=left ventricular ejection fraction; MACCE=major adverse cardiac/cerebrovascular event; mg=milligrams; MI=myocardial infarction; mini-CABG=minimally invasive coronary artery bypass grafting (robotic); mL=millilitres; MVr=mitral valve repair; N=sample size; NS=not significant; OPCAB=off-pump coronary artery bypass via sternotomy; OR=operating room; PCA=patient controlled analgesia; PSA=prostate-specific antigen; PVD=peripheral vascular disease; QALY=quality-adjusted life year; SCC=Squamous cell carcinoma; SD=standard deviation; TNM=tumour, node, metastasis; Tests of significance are for comparisons between all groups unless otherwise noted.

Table A25: Results and Limitations of Economic Studies			
Author / Year of Publication	**Sensitivity Analysis Results**	**Author Conclusions**	**Limitations**
Bolenz et al. (2010)[139]	Sensitivity analysis not conducted	Obesity resulted in higher costs in patients who underwent open and laparoscopic prostatectomy. Obesity did not affect costs in patients undergoing RALP	Retrospectively collected data from single centre. Cost components not completely described. Cost of robotic equipment not considered.
Hohwü et al. (2010)[140]	Authors reported that the outcome was not affected by the parameters tested in the sensitivity analysis. Parameters tested and their results were not described.	Robotic prostatectomy more costly but more effective. There were no QALY gains with robotic surgery after one year. Focus on cost-effectiveness may be to perform robotic surgery on fewer high-volume centres to utilize the full potential of each robot machine and increase the effectiveness of robotic surgery.	Limited data as from an abstract. Retrospective analysis using data from a single centre. Costs considered in analysis not specified.
Laungani et al. (2010)[142]	Sensitivity analysis not conducted	For community hospitals, investment in a robotic	Limited data as from an abstract. Retrospective analysis using data

Table A25: Results and Limitations of Economic Studies			
Author / Year of Publication	**Sensitivity Analysis Results**	**Author Conclusions**	**Limitations**
		surgical system can be a daunting and expensive task, however over a 1-2 year period benefits can extend to community hospital system in the form of decreased costs and charges, more efficient care, and excellent patient outcomes.	from a single centre. Costs considered in analysis not specified.
Bolenz et al. (2010)[129]	Sensitivity analysis not conducted	RALP is associated with higher cost, predominantly due to increased operating room cost and surgical supply cost. These costs may have a significant impact on overall cost of prostate cancer care.	Data from a single centre. Retrospective. Purchase cost and maintenance of robot not incorporated into the analysis.
Lotan et al. (2010)[143]	Sensitivity analysis not conducted	The introduction of RALP increased case volume at this hospital and improved profits for the surgeon. The hospital loses money on each LRP and RALP case compared with RRP, which provides a small profit.	Data from a single centre. Retrospective analysis. Cost of robot not included in analysis.
Ollendorf et al. (2009)[130]	Sensitivity analysis not reported	Robot-assisted radical prostatectomy is less expensive and more effective then open radical prostatectomy	Cost of robot, maintenance, and disposables not considered in the analysis. Analysis assumed maximal effectiveness while evidence for superiority of robotic-assisted prostatectomy insufficient.
Joseph et al. (2008)[141]	Sensitivity analysis not conducted	The costs associated with LRP an RAP are significantly higher than those of open surgery. They are, however, associated with shorter LOS from which the hospital benefits. Offering new technologies has its costs and benefits, and medical cost inflation deserves further study.	Single centre, retrospective analysis, consequences of robotic surgery not equally quantified or reported.
Steinberg et al. (2008)[131]	At all levels of baseline productivity, purchase of a robot requires greater case volume to maintain profits, relative to donation of a robot.	Data suggests that a high-volume LRP program can convert to RAP and maintain profits, however, the cost of the robot precludes equal income as that with LRP. Purchasing a robot is not fiscally viable in a low-volume program.	Single centre. Assumptions regarding equivalence of outcomes and other costs (ex: OR time). Sensitivity analysis unclear. Exclusion of learning curve and impact of trainees from analysis may have made RAP appear more profitable than it really was.
Mayer et al.	Sensitivity analysis not	The current national tariff	Limited data as from an abstract.

Table A25: Results and Limitations of Economic Studies			
Author / Year of Publication	**Sensitivity Analysis Results**	**Author Conclusions**	**Limitations**
(2007)[132]	conducted	system does not distinguish between the three surgical approaches for radical prostatectomy and reimbursement is made at £3,701 irrespective of the higher 'true' costs of conventional laparoscopic and particularly robot-assisted approaches. Health care managers have very difficult business decisions to make with regard to the implementation of innovative technology, such as minimally invasive radical prostatectomy, when overwhelming patient-oriented benefits are lacking.	Single centre. Cost of robotic equipment not considered in the analysis.
Mouraviev et al. (2007)[133]	Sensitivity analysis not conducted	Despite the relatively increased surgical expense of CAP compared with conventional surgical prostatectomy and laparoscopy, the overall direct costs were offset by the significantly lower nonoperative hospital costs. Cost advantages associated with CAP included shorter length of stay and absence of pathological costs and the need for blood transfusion.	Single centre. Retrospective. Cost of robotic equipment not accounted for. Indirect costs not clearly described. Learning curve for robotic prostatectomy and CAP during study period. Early postoperative care of robotic prostatectomy patients was conservative and length of stay has decreased since.
O'Malley et al. (2007)[134]	Sensitivity analysis not conducted	This case study of robotic-assisted laparoscopic radical prostatectomy demonstrates that there is sufficient crude evidence to show that this new procedure is likely to be superior to the existing procedure in terms of safety, effectiveness, and cost-effectiveness.	Retrospective. The derivation of QALYs and the estimation of the incremental cost per QALY is unclear. Calculations for the cost of incontinence and erectile dysfunction are confused with the cost of treatment of prostatectomy in-hospital. Health care costs post-discharge not considered.
Burgess et al. (2006)[135]	Sensitivity analysis not conducted	Robot-assisted prostatectomy is associated with substantially higher operative and total hospital charges in addition to the capital expense incurred by the hospital in acquiring and maintaining the robotic system. The operative charges did decrease substantially	Single centre. Retrospective. Unclear if cost of robotic equipment and maintenance accounted for in costs. Learning curve for robotic prostatectomy may overestimate operative costs in an experienced robotic surgical team. Small sample size. Analysis based on hospital charges.

Table A25: Results and Limitations of Economic Studies			
Author / Year of Publication	**Sensitivity Analysis Results**	**Author Conclusions**	**Limitations**
		(27%) once the learning curve had been overcome. Perineal prostatectomy remains the most cost-effective procedure, with lower operative operative costs and shorter times. There was no significant difference in the nonoperative charges in the three treatment groups secondary to the short hospital stay.	
Scales et al. (2005)[136]	Model was sensitive to changes in operative time, LOS, daily room costs, and case volume, and cost-equivalency points between RAP and generalist and specialist centres were demonstrated. For example, RAP could achieve cost equivalence with RRP generalist centres at a surgical volume of 10 cases weekly, and with RRP specialist centres at a volume of 15 cases weekly (basecase=7 cases/week).	The current cost model suggests that robotic prostatectomy costs are volume dependent and cost equivalence with radical retropubic prostatectomy is possible at certain case volumes. Contrasting findings with previous studies demonstrate the importance of local cost structures for this comparison. While radical retropubic prostatectomy in the specialist setting is the lowest cost scenario, the model implies that robotic prostatectomy at high volume specialty centres may be cost-competitive with radical retropubic prostatectomy in the community.	Operative times for radical retropubic prostatectomy were obtained from published reports and could potentially underestimate operative times in the community, thus overestimating the cost premium for robot-assisted prostatectomy. Post-anesthesia care costs were estimated from a single centre and may not be generalizable to all settings.
Guru et al. (2004)[137]	Sensitivity analysis not conducted	Cost for the robotic-assisted laparoscopic prostatectomy was found to be similar to that for the radical retropubic prostatectomy procedure at our institutions. The cost is greater if the depreciation of the robot and service contract costs is included.	Information obtained from abstract and therefore limited in detail. Retrospective. Cost data not provided. Small sample size. Unclear if cost of disposables and consumables included.
Lotan et al. (2004)[138]	At current robot costs there was no individual decrease in LOS or OR time that would make robotic cost-equivalent to open surgery in 1-way analyses. Two-way analyses found that if robotic surgery were performed as an	The costs of new technology are typically borne out in the first years of use and robotic assisted prostatectomy is no exception with high robot costs for purchase, maintenance and operative equipment overshadowing savings gained by shorter lengths of stay. While radical	Outcomes data obtained from published sources, and methods used to derive estimates not provided.

Table A25: Results and Limitations of Economic Studies			
Author / Year of Publication	**Sensitivity Analysis Results**	**Author Conclusions**	**Limitations**
	outpatient procedure it would have to be performed in less than 1 hour to achieve cost-equivalence with open surgery (base case operating room time for robotic surgery is 140 minutes). Robot equipment costs would have to decrease to $500,000 and annual maintenance contract to $34,000 to be cost-equivalent to open surgery. Increase of caseload from 300 to 500 cases per year was insufficient to achieve equivalence with open or laparoscopic.	retropubic prostatectomy is currently the least costly approach, laparoscopic prostatectomy has proved to be almost as cost competitive as radical retropubic prostatectomy, whereas robotic assisted prostatectomy will require a significant decrease in the cost of the device and maintenance fees.	
Bachinsky et al. (2010)[144]	Sensitivity analysis not conducted	Same-sitting robotic HCR is feasible and may offer superior outcomes compared to the standard OPCAB or staged HCR in some patients with multi-vessel CAD, further studie are warranted.	Information obtained from abstract and therefore limited in detail. Small sample size. Single centre. Details on included or treatment of robot costs not provided.
Kam et al. (2010)[119]	Sensitivity analysis not conducted	Robotic mitral valve repair can be performed with similar repair success rates as conventional surgery with a shorter recovery time, but slightly longer operative time. There is no significant increase in cost over conventional surgery.	Retrospective study. Capital cost and maintenance of robotic equipment not included.
Poston et al. (2008)[123]	Sensitivity analysis not conducted	In exchange for increasing intraoperative costs relative to OPCAB, the use of robotic assistance ± PCI during mini-CABG provide 3 advantages: (1) broaden the number of candidates requiring multivessel revascularization that are suitable for a minimally invasive approach, (2) reduce postoperative costs, and (3) improve quality of life metrics immediately after surgery and through the first	Patients not randomized to groups; 78% follow-up at one year and so possibility of selection bias; enthusiasm for mini-CABG may have influenced cost drivers (extubation times, LOS stay, transfusions) at this institution.

Table A25: Results and Limitations of Economic Studies			
Author / Year of Publication	**Sensitivity Analysis Results**	**Author Conclusions**	**Limitations**
		postoperative year. Although the long-term value of this strategy compared with conventional approach remains to be investigated, concerns over hospital costs should not deter its use in appropriate candidates.	
Morgan et al. (2005)[145]	Sensitivity analysis not conducted	Robotic technology did not significantly increase hospital costs. While the absolute cost for robotic surgery was higher than conventional techniques after taking into account the institutional cost of the robot, the major driver of cost for robotic procedures will likely continue to decrease, and the surgical team becomes increasingly familiar with robotic technology. Other benefits such as improvement in postoperative quality of life and more expeditious return to work may make a robotic approach cost-effective. Thus it is possible that the benefits of robotic surgery may justify investment in this technology.	Single centre. Small sample size. Retrospective analysis.
Boger et al. (2010)[146]	Sensitivity analysis not conducted	Early experience with robotic assistance for radical and simple nephrectomy offers no significant advantage over traditional or hand-assisted approaches, and was more costly.	Single centre. Retrospective. Small sample size. Cost of robot and its maintenance not considered in the analysis.
Nazemi et al. (2006)[115]	Sensitivity analysis not conducted	Radical nephrectomy can be performed using either open, robotic, or laparoscopy with or without hand assistance by a single surgeon without significant difference in perioperative complication rates.	Single centre. Retrospective. Long-term oncological outcomes not evaluated. Small sample size. Costs obtained from subset of patients for whom data were available. Limited detail on content of perioperative and total hospital costs. Unclear whether cost of robot was included in the analysis.
Prewitt et al. (2008)[58]	Sensitivity analysis not conducted	Average direct cost of robotic surgery over all indications was $1,470 per patient. Higher cost of robotic surgery due to	Retrospective analysis. Small sample sizes for robotic procedures. Treatment of robot costs not clear. Details of included costs not

Table A25: Results and Limitations of Economic Studies			
Author / Year of Publication	**Sensitivity Analysis Results**	**Author Conclusions**	**Limitations**
		specialized equipment. Average four-day reduction in length of stay merits further exploration.	provided. Patient outcomes not considered.
Barnett et al. (2010)[147]	Hospital perspective models: most sensitive to cost of robotic disposable equipment, length of stay, operative time Societal perspective model: most sensitive to cost of disposable robotic equipment and recovery time from robotic surgery	Laparoscopy is the least expensive surgical approach for the treatment of endometrial cancer. Robotic is less costly than open surgery when the societal costs associated with recovery time are accounted for, and is most economically attractive if disposable equipment costs can be minimized.	Complications not incorporated in analysis. Most baseline clinical parameters based on single study.
Halliday et al. (2010)[86]	Open/Robotic Total average costs Without cost of robot: \$11,764±\$6,790/\$8,183± \$1,089 (P=0.002) With caseload of 10/wk (520/year): \$11,764±\$6,790/\$8,898± \$1,089 (NS)	Whereas robotic hysterectomy takes longer to perform than traditional laparotomy, it provides the patient with a shorter hospital stay, less need for pain medication, and reduced perioperative morbidity. In addition, average hospital costs tend to be lower.	Single centre. Retrospective data collection for open procedures. Small sample size.
Holtz et al. (2010)[96]	Sensitivity analysis not conducted	Robotic surgical costs were significantly higher than traditional laparoscopy costs for staging of endometrial cancer in this small cohort of patients.	Single centre. Retrospective data. Small sample size. Costs not clearly itemized. Cost of robot and its maintenance not included.
Pasic et al. (2010)[148]	Sensitivity analysis not conducted	Findings reveal little clinical difference in perioperative and postoperative events. This coupled with increased per-case hospital cost of the robot suggest further investigation is warranted when considering this technology for routine laparoscopic hysterectomies. Randomized controlled trials are needed.	Details on costs not provided. Cost of robot not included. Unclear if cost of disposables included.
Raju et al. (2010)[149]	Sensitivity analysis not conducted	Robotic-assisted hysterectomy compared favourably with other surgical hysterectomy techniques, and is a safe and	Single centre. Small sample size. Data on laparoscopic and open procedures obtained retrospectively. Descriptive patient and outcome data

Table A25: Results and Limitations of Economic Studies			
Author / Year of Publication	**Sensitivity Analysis Results**	**Author Conclusions**	**Limitations**
		feasible and safe surgical technique with all the advantages of minimal access surgery and equivalent cost.	not provided for laparoscopic and open groups. Method used to estimate robot costs unclear.
Wright et al. (2010)[150]	Sensitivity analysis not conducted	Method of hysterectomy is an important factor on the LOS, complication rate, operative costs, and total cost of stay. Operative time and operative costs most strongly associated with BMI rather than method of hysterectomy.	Information obtained from abstract and therefore limited in detail. Retrospective. Details on included costs not provided, particularly with respect to robotic equipment and supplies.
Sarlos et al. (2010)[151]	Sensitivity analysis not conducted	Robot-assisted hysterectomy is a feasible and interesting new technique with comparable outcome to total laparoscopic hysterectomy. Cost of robotic surgery are still higher than for conventional laparoscopy.	Single centre. Retrospective. Small sample size. Cost of robot not included.
Bell et al. (2008) [102]	Sensitivity analysis not conducted	Robotic hysterectomy provides comparable node retrieval to laparotomy and laparoscopic procedures in the case of the experienced laparoscopic surgeon. While robotic hysterectomy takes longer to perform than hysterectomy completed via laparotomy, it is equivalent to laparoscopic hysterectomy and provides the patient a more expeditious return to normal activity with reduced postoperative morbidity. The average cost for hysterectomy and staging was highest for laparotomy, followed by robotic, and least for standard laparoscopy.	Single centre. Retrospective. Expected case load per year for determining expected cost per case among robotic patients not stated.

BMI=body mass index; CAD=coronary artery disease; CAP=cryosurgical ablation of the prostate; HCR=Hybrid coronary artery revascularization ; LOS=length of stay; LRP=laparoscopic radical prostatectomy; mini-CABG=minimally invasive coronary artery bypass grafting (robotic); OPCAB=off-pump coronary artery bypass via sternotomy; OR=operating room; PCI=percutaneous coronary interventions; QALY=quality-adjusted life-year; RALP=robotic-assisted laparoscopic prostatectomy; RAP=robotic-assisted prostatectomy; RRP=radical retropubic prostatectomy

Appendix 18: Undiscounted Per-centre Costs of da Vinci Robot, Maintenance, Consumables, and Training, by Year

Table A26: Undiscounted Per-centre Costs of da Vinci Robot, Maintenance, Consumables, and Training, by Year

Item	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7*	Year 8	Year 9	Year 10
Da Vinci Si Surgical System	$2,643,680	-	-	-	-	-	-	-	-	-
Start-up reusable equipment and accessories	$203,360	-	-	-	-	-	-	-	-	-
Disposables/ consumables	$330,460	$330,460	$330,460	$330,460	$330,460	$330,460	$330,460	$330,460	$330,460	$330,460
Surgeon training	-	$6,101	$6,101	$6,101	$6,101	$6,101	$6,101	$6,101	$6,101	$6,101
Annual maintenance	-	$177,940	$177,940	$177,940	$177,940	$177,940	$177,940	$177,940	$177,940	$177,940
Annual total costs	$3,177,550	$514,501	$514,501	$514,501	$514,501	$514,501	$514,501	$514,501	$514,501	$514,501
Cumulative total costs	$3,177,550	$3,692,001	$4,206,502	$4,721,002	$5,235,503	$5,750,004	$6,264,505	$6,779,006	$7,293,506	$7,808,007

*Expected average life of equipment in base case analysis. Cost of disposables/consumables based on assumption of average of 130 cases per centre per year. All costs given in 2011 Canadian dollars.

Appendix 19: Resource Utilization and Costs in the Economic Evaluation

Table A27: Resource Utilization

Resource	Comparison	
	RALP vs. ORP	RALP vs. LRP
Length of hospital stay		
RALP	2.604	4.130
ORP	4.144	-
LRP	-	4.930
Probability of blood transfusion		
RALP	2.9%	2.5%
ORP	14.5%	-
LRP	-	4.6%
Units of blood per transfusion		
RALP	1	1
ORP	2	-
LRP	-	1

All estimates obtained from meta-analysis of clinical data in this report. RALP=robot-assisted radical prostatectomy; ORP=open radical prostatectomy; LRP=laparoscopic radical prostatectomy.

Table A28: Costs

Resource	Comparison		Source
	RALP vs. ORP	RALP vs. LRP	
Surgical equipment/supplies (per patient)			
RALP*	$7,427	$7,427	Minogue§
ORP	$212	-	[129]
LRP	-	$831	[129]
Hospital per diem for prostatectomy	$2,353	$2,353	CIHI*f*
Unit of red blood cells	$429.23	$429.23	[171]
Surgical fees (per procedure)			[167-170]
RALP	$1381	$1381	
ORP	$1022	-	
LRP	-	$1381	
Anesthesia (per procedure)			[167-170]
RALP	$581	$581	
ORP	$470	-	
LRP	-	$615	

*Assumed annual caseload of 130 procedures robot useful life of seven years. RALP=robot-assisted radical prostatectomy; ORP=open radical prostatectomy; LRP=laparoscopic radical prostatectomy;
§(Danny Minogue, Minogue Medical Inc., Montreal, QC: personal communication, 2010 December 31)
f(Sources: Canadian Institute for Health Information, Ottawa, ON, Canada. Discharge Abstract Database (DAD))

Appendix 20: Parameter Estimates Used in the Probabilistic Sensitivity Analysis

Table A29: Distribution of Probabilities				
Model	**Variable**	**Alpha**	**Beta**	**Probability**
RALP vs. ORP	P(transfusion|RALP)	137	4710	0.0290
	P(transfusion|ORP)	583	4020	0.1450
RALP vs. LRP	P(transfusion|RALP)	23	904	0.0250
	P(transfusion|LRP)	42	916	0.0463
RALP=robot-assisted radical prostatectomy; ORP=open radical prostatectomy; LRP=laparoscopic radical prostatectomy. All probabilities assumed to follow beta distribution.				

Table A30: Distribution of Costs and Lengths of Stay					
Model	**Variable**	**Mean**	**SE**	**Alpha**	**Beta**
RALP vs. ORP	RALP equipment	7427	-	-	-
	ORP equipment	212	-	-	-
	Per diem	2353	1176	4	588
	Surgery fees RALP	1381	691	4	345
	Surgery fees ORP	1022	511	4	256
	Anesthesia RALP	581	291	4	145
	Anesthesia ORP	470	235	4	117
	Unit red blood cells	429	215	4	107
	LOS RALP	2.604	0.258	101.9	0.0256
	LOS ORP	4.144	0.561	54.5	0.0761
RALP vs. LRP	RALP equipment	7427	-	-	-
	LRP equipment	831	-	-	-
	Per diem	2353	1176	4	588
	Surgery fees RALP	1381	691	4	345
	Surgery fees LRP	1381	691	4	345
	Anesthesia RALP	581	291	4	145
	Anesthesia LRP	615	307	4	154
	Unit red blood cells	429	215	4	107
	LOS RALP	4.130	0.762	29.4	0.1406
	LOS ORP	4.930	1.032	22.8	0.2161
RALP=robot-assisted radical prostatectomy; ORP=open radical prostatectomy; LRP=laparoscopic radical prostatectomy; LOS=length of stay. Costs of surgical equipment assumed to be fixed. All other costs assumed to follow gamma distribution. Length of stay assumed to follow gamma distribution.					

Appendix 21: Potential Annual Population Impact

Table A31: Potential Annual Population Impact (Cases) for Robotic Surgery with the Da Vinci Robot, Assuming 268 Annual Surgeries per Institution, by Hospital Teaching Status and Size, and Procedure, Canada							
Hospital Characteristics		**Procedure Type**					
Teaching Status	**Beds**	**Cardiac**	**Prost.**	**Hyst.**	**Neph.**	**Other**	**Total**
Teaching	300-399	133	1,497	554	76	152	2,412
	*400+**	*458*	*5,158*	*1,909*	*261*	*522*	*8,308*
	Total	591	6,655	2,463	337	674	10,720
Non-teaching	300-399	325	3,660	1,355	185	371	5,896
	400+	340	3,827	1,416	194	387	6,164
	Total	665	7,487	2,771	379	758	12,060
All hospitals		1,257	14,142	5,234	716	1,432	22,780

The maximum number of annual procedures at a Canadan centre in 2010=268.
*Base case institution; Prost=Prostatectomy; Hyst=Hysterectomy; Neph=Nephrectomy

Table A32: Potential Annual Population Impact (Cases) for Robotic Surgery with the Da Vinci Robot, Assuming 365 Annual Surgeries per Institution, by Hospital Teaching Status and Size, and Procedure, Canada							
Hospital Characteristics		**Procedure Type**					
Teaching Status	**Beds**	**Cardiac**	**Prost.**	**Hyst.**	**Neph.**	**Other**	**Total**
Teaching	300-399	181	2,039	755	103	206	3,285
	*400+**	*624*	*7,024*	*2,600*	*356*	*711*	*11,315*
	Total	805	9,064	3,354	459	918	14,600
Non-teaching	300-399	443	4,985	1,845	252	505	8,030
	400+	624	7,024	2,600	356	711	11,315
	Total	1,067	12,010	4,444	608	1,216	19,345
All hospitals		1,873	21,073	7,799	1,067	2,133	33,945

Assumption is one case per centre per day.
*Base case institution; Prost=Prostatectomy; Hyst=Hysterectomy; Neph=Nephrectomy

Appendix 22: Estimated Costs of Surgical Equipment, by Indication

Table A33: Per-patient Costs of Disposable Open and Laparoscopic Surgical Equipment, by Indication		
Indication	**Open**	**Robotic**
Prostatectomy	$212[129]	$831[151]
Hysterectomy	$225[86,147]	$1155[96,147,151]
Cardiac procedures	$218*	NA
Nephrectomy	$218*	$1802[146]

*Estimated based on prostatectomy and hysterectomy. NA=not applicable

Appendix 23: Hospital Budget Impact

Table A34: Hospital Budget Impact of Robotic Surgery Program Based on Average Canadian Patient, by Annual Caseload and Useful Life of Robotic Equipment				
Annual Caseload	Costs	Useful Life of Robotic Equipment		
		5 Years	7 Years	10 Years
50	Robot costs	$421,8703	$4,840,985	$5,774,407
	Other surgical disposables	$132,641	$185,697	$265,281
	Hospital stay savings	$787,589	$1,102,625	$1,575,178
	Net program costs	$3,298,473	$3,552,663	$3,933,947
100	Robot costs	$4,854,203	$5,730,685	$7,045,407
	Other surgical disposables	$265,281	$371,394	$530,563
	Hospital stay savings	$1,575,178	$2,205,250	$3,150,357
	Net program costs	$3,013,743	$3,154,041	$3,364,488
150	Robot costs	$5,489,703	$6,620,385	$8,316,407
	Other surgical disposables	$397,922	$557,091	$795,844
	Hospital stay savings	$2,362,768	$3,307,875	$4,725,535
	Net program costs	$2,729,014	$2,755,419	$2,795,028
200	Robot costs	$6,125,203	$7,510,085	$9,587,407
	Other surgical disposables	$530,563	$742,788	$1,061,125
	Hospital stay savings	$3,150,357	$4,410,500	$6,300,714
	Net program costs	$2,444,284	$2,356,797	$2,225,568
250	Robot costs	$6,760,703	$8,399,785	$10,858,407
	Other surgical disposables	$663,203	$928,485	$1,326,406
	Hospital stay savings	$3,937,946	$5,513,125	$7,875,892
	Net program costs	$2,159,554	$1,958,176	$1,656,108
300	Robot costs	$7,396,203	$9,289,485	$12,129,407
	Other surgical disposables	$795,844	$1,114,181	$1,591,688
	Hospital stay savings	$4,725,535	$6,615,750	$9,451,071
	Net program costs	$1,874,824	$1,559,554	$1,086,649
400	Robot costs	$8,667,203	$11,068,885	$14,671,407
	Other surgical disposables	$1,061,125	$1,485,575	$2,122,250
	Hospital stay savings	$6,300,714	$8,820,999	$12,601,428
	Net program costs	$1,305,364	$762,310	-$52,271
500	Robot costs	$9,938,203	$12,848,285	$17,213,407
	Other surgical disposables	$1,326,406	$1,856,969	$2,652,813
	Hospital stay savings	$7,875,892	$11,026,249	$15,751,785
	Net program costs	$735,904	-$34,934	-$1,191,191

Table A35: Hospital Budget Impact of Robotic Surgery Program in Prostatectomy, by Annual Caseload and Useful Life of Robotic Equipment				
Annual Caseload	Costs	Useful Life of Robotic Equipment		
		5 Years	7 Years	10 Years
50	Robot costs	$4,218,703	$4,840,985	$5,774,407
	Other surgical disposables	$167,891	$235,047	$335,781
	Hospital stay savings	$597,056	$835,879	$1,194,113
	Net program costs	$3,453,756	$3,770,059	$4,244,513
100	Robot costs	$4,854,203	$5,730,685	$7,045,407
	Other surgical disposables	$335,781	$470,094	$671,563
	Hospital stay savings	$1,194,113	$1,671,758	$2,388,226
	Net program costs	$3,324,309	$3,588,833	$3,985,619
150	Robot costs	$5,489,703	$6,620,385	$8,316,407
	Other surgical disposables	$503,672	$705,141	$1,007,344
	Hospital stay savings	$1,791,169	$2,507,637	$3,582,339
	Net program costs	$3,194,862	$3,407,607	$3,726,725
200	Robot costs	$6,125,203	$7,510,085	$9,587,407
	Other surgical disposables	$671,563	$940,188	$1,343,125
	Hospital stay savings	$2,388,226	$3,343,516	$4,776,452
	Net program costs	$3,065,415	$3,226,381	$3,467,830
250	Robot costs	$6,760,703	$8,399,785	$10,858,407
	Other surgical disposables	$839,453	$1,175,235	$1,678,906
	Hospital stay savings	$2,985,282	$4,179,395	$5,970,564
	Net program costs	$2,935,968	$3,045,155	$3,208,936
300	Robot costs	$7,396,203	$9,289,485	$12,129,407
	Other surgical disposables	$1,007,344	$1,410,281	$2,014,688
	Hospital stay savings	$3,582,339	$5,015,274	$7,164,677
	Net program costs	$2,806,521	$2,863,929	$2,950,042
400	Robot costs	$8,667,203	$11,068,885	$14,671,407
	Other surgical disposables	$1,343,125	$1,880,375	$2,686,250
	Hospital stay savings	$4,776,452	$6,687,032	$9,552,903
	Net program costs	$2,547,626	$2,501,477	$2,432,254
500	Robot costs	$9,938,203	$12,848,285	$17,213,407
	Other surgical disposables	$1,678,906	$2,350,469	$3,357,813
	Hospital stay savings	$5,970,564	$8,358,790	$11,941,129
	Net program costs	$2,288,732	$2,139,025	$1,914,465

Table A36: Hospital Budget Impact of Robotic Surgery Program in Hysterectomy, by Annual Caseload and Useful Life of Robotic Equipment				
Annual Caseload	**Costs**	**Useful Life of Robotic Equipment**		
		5 Years	**7 Years**	**10 Years**
50	Robot costs	$4,218,703	$4,840,985	$5,774,407
	Other surgical disposables	$78,656	$110,118	$157,312
	Hospital stay savings	$1,136,565	$1,591,191	$2,273,130
	Net program costs	$3,003,482	$3,139,675	$3,343,965
100	Robot costs	$4,854,203	$5,730,685	$7,045,407
	Other surgical disposables	$157,312	$220,236	$314,623
	Hospital stay savings	$2,273,130	$3,182,382	$4,546,260
	Net program costs	$2,423,761	$2,328,066	$2,184,523
150	Robot costs	$5,489,703	$6,620,385	$8,316,407
	Other surgical disposables	$235,967	$330,354	$471,935
	Hospital stay savings	$3,409,695	$4,773,573	$6,819,391
	Net program costs	$1,844,040	$1,516,457	$1,025,082
200	Robot costs	$6,125,203	$7,510,085	$9,587,407
	Other surgical disposables	$314,623	$440,473	$629,247
	Hospital stay savings	$4,546,260	$6,364,765	$9,092,521
	Net program costs	$1,264,319	$704,848	-$134,360
250	Robot costs	$6,760,703	$8,399,785	$10,858,407
	Other surgical disposables	$393,279	$550,591	$786,558
	Hospital stay savings	$5,682,826	$7,955,956	$11,365,651
	Net program costs	$684,599	-$106,762	-$1,293,802
300	Robot costs	$7,396,203	$9,289,485	$12,129,407
	Other surgical disposables	$471,935	$660,709	$943,870
	Hospital stay savings	$6,819,391	$9,547,147	$13,638,781
	Net program costs	$104,878	-$918,371	-$2,453,244
400	Robot costs	$8,667,203	$11,068,885	$14,671,407
	Other surgical disposables	$629,247	$880,945	$1,258,493
	Hospital stay savings	$9,092,521	$12,729,529	$18,185,042
	Net program costs	-$1,054,564	-$2,541,590	-$4,772,128
500	Robot costs	$9,938,203	$12,848,285	$17,213,407
	Other surgical disposables	$786,558	$1,101,181	$1,573,116
	Hospital stay savings	$11,365,651	$15,911,912	$22,731,302
	Net program costs	-$2,214,006	-$4,164,808	-$7,091,011

Table A37: Hospital Budget Impact of Robotic Surgery Program in Cardiac Procedures, by Annual Caseload and Useful Life of Robotic Equipment				
Annual Caseload	**Costs**	**Useful Life of Robotic Equipment**		
		5 Years	**7 Years**	**10 Years**
50	Robot costs	$4,218,703	$4,840,985	$577,4407
	Other surgical disposables	$54,612	$76,457	$109,225
	Hospital stay savings	$1,429,256	$2,000,959	$2,858,513
	Net program costs	$2,734,835	$2,763,569	$2,806,670
100	Robot costs	$4,854,203	$5,730,685	$7,045,407
	Other surgical disposables	$109,225	$152,915	$218,450
	Hospital stay savings	$2,858,513	$4,001,918	$5,717,025
	Net program costs	$1,886,466	$1,575,853	$1,109,933
150	Robot costs	$5,489,703	$6,620,385	$8,316,407
	Other surgical disposables	$163,837	$229,372	$327,674
	Hospital stay savings	$4,287,769	$6,002,876	$8,575,538
	Net program costs	$1,038,097	$388,136	-$586,805
200	Robot costs	$6,125,203	$7,510,085	$9,587,407
	Other surgical disposables	$218,450	$305,829	$436,899
	Hospital stay savings	$5,717,025	$8,003,835	$11,434,050
	Net program costs	$189,729	-$799,580	-$2,283,542
250	Robot costs	$6,760,703	$8,399,785	$10,858,407
	Other surgical disposables	$273,062	$382,287	$546,124
	Hospital stay savings	$7,146,281	$10,004,794	$14,292,563
	Net program costs	-$658,640	-$1,987,296	-$3,980,279
300	Robot costs	$7,396,203	$9,289,485	$12,129,407
	Other surgical disposables	$327,674	$458,744	$655,349
	Hospital stay savings	$8,575,538	$12,005,753	$17,151,075
	Net program costs	-$1,507,009	-$3,175,012	-$5,677,017
400	Robot costs	$8,667,203	$11,068,885	$14,671,407
	Other surgical disposables	$436,899	$611,659	$873,798
	Hospital stay savings	$11,434,050	$16,007,670	$22,868,100
	Net program costs	-$3,203,746	-$5,550,444	-$9,070,491
500	Robot costs	$9,938,203	$12,848,285	$17,213,407
	Other surgical disposables	$546,124	$764,574	$1,092,248
	Hospital stay savings	$14,292,563	$20,009,588	$28,585,125
	Net program costs	-$4,900,483	-$7,925,877	-$12,463,966

Table A38: Hospital Budget Impact of Robotic Surgery Program in Nephrectomy, by Annual Caseload and Useful Life of Robotic Equipment				
Annual Caseload	Costs	Useful Life of Robotic Equipment		
		5 Years	7 Years	10 Years
50	Robot costs	$4,218,703	$4,840,985	$5,774,407
	Other surgical disposables	$247,079	$345,911	$494,158
	Hospital stay savings	$913,256	$1,278,559	$1,826,513
	Net program costs	$3,058,368	$3,216,515	$3,453,736
100	Robot costs	$4,854,203	$5,730,685	$7,045,407
	Other surgical disposables	$494,158	$691,821	$988,316
	Hospital stay savings	$1,826,513	$2,557,118	$3,653,026
	Net program costs	$2,533,532	$2,481,745	$2,404,065
150	Robot costs	$5,489,703	$6,620,385	$8,316,407
	Other surgical disposables	$741,237	$1,037,732	$1,482,475
	Hospital stay savings	$2,739,769	$3,835,677	$5,479,538
	Net program costs	$2,008,697	$1,746,976	$1,354,394
200	Robot costs	$6,125,203	$7,510,085	$9,587,407
	Other surgical disposables	$988,316	$1,383,643	$1,976,633
	Hospital stay savings	$3,653,026	$5,114,236	$7,306,051
	Net program costs	$1,483,861	$1,012,206	$304,723
250	Robot costs	$6,760,703	$8,399,785	$10,858,407
	Other surgical disposables	$1,235,395	$1,729,554	$247,0791
	Hospital stay savings	$4,566,282	$6,392,795	$9,132,564
	Net program costs	$959,026	$277,436	-$744,948
300	Robot costs	$7,396,203	$9,289,485	$12,129,407
	Other surgical disposables	$1,482,475	$2,075,464	$2,964,949
	Hospital stay savings	$5,479,538	$7,671,354	$10,959,077
	Net program costs	$434,190	-$457,333	-$1,794,619
400	Robot costs	$8,667,203	$11,068,885	$14,671,407
	Other surgical disposables	$1,976,633	$2,767,286	$3,953,265
	Hospital stay savings	$7,306,051	$10,228,472	$14,612,103
	Net program costs	-$615,481	-$1,926,873	-$3,893,961
500	Robot costs	$9,938,203	$12,848,285	$17,213,407
	Other surgical disposables	$2,470,791	$3,459,107	$4,941,582
	Hospital stay savings	$9,132,564	$12,785,590	$1,8265,128
	Net program costs	-$1,665,152	-$3,396,412	-$5,993,303